NATIONAL POLAR-ORBITING OPERATIONAL ENVIRONMENTAL SATELLITE SYSTEM (NPOESS)

OPERATIONAL ALGORITHM DESCRIPTION DOCUMENT FOR CrIMSS EDR (D37021 Rev A)

CDRL No. A032

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A1	5-11-06	15Sep05 – Reflects Raytheon-Omaha's Initial Completion of the Science To Operational (Sci2Ops) Code Conversion Process 21Feb06 – Per a follow-on EH/OPT DDPR comment, inserted a table under Section 2.4 Graceful Degradation. 11Apr06 – Made minor edits to address comments from the Follow-on CCPR held 11 Apr 06. 19Apr06 – Added tables to show AVTP and AVMP reporting pressures and vertical cell size, PP reporting altitudes, and OSS pressure levels. 08May06 – Made format edits in preparation for delivery to NGST as a follow-on document. 11May06 – Sent document to NPOESS_CM for official delivery to NGST as a follow-on document.	All
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A4	12-17-07	ECR A-103, EDR-PR CP3, and CDFCB-X compliance updates: added description of the terrain-corrected geolocation output.	9
A5	1-24-08	Delivered to NGST.	All
A6	5-14-08	Prepare for delivery to ACCB. Implemented new cover sheet from NGST.	All
A	05-28-08	Addressed comments from Xia-Lin Ma for ACCB approval, incorporating interim changes above with ECR A-156. Approved for Public Release per Contracts letter 090618-01	All

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1.0 INTRODUCTION

1.1 Objective

The purpose of the Operational Algorithm Description (OAD) document is to express, in computer-science terms, the remote sensing algorithms that produce the National Polar-Orbiting Operational Environmental Satellite System (NPOESS) end-user data products. These products are individually known as Raw Data Records (RDRs), Temperature Data Records (TDRs), Sensor Data Records (SDRs) and Environmental Data Records (EDRs). In addition, any Intermediate Products (IPs) produced in the process are also described in the OAD.

The science basis of an algorithm is described in a corresponding Algorithm Theoretical Basis Document (ATBD). The OAD provides a software description of that science as implemented in the operational ground system --- the Data Processing Element (DPE).

The purpose of an OAD is two-fold:

1. Provide initial implementation design guidance to the operational software developer
2. Capture the "as-built" operational implementation of the algorithm reflecting any changes needed to meet operational performance/design requirements

An individual OAD document describes one or more algorithms used in the production of one or more data products. There is a general, but not strict, one-to-one correspondence between OAD and ATBD documents. This particular document describes operational software implementation for the Cross-track Infrared and Advanced Technology Microwave Sounder Suite (CrIMSS), Atmospheric Vertical Temperature Profile (AVTP), Atmospheric Vertical Moisture Profile (AVMP), and Pressure Profile (PP) Environmental Data Records (EDRs).

1.2 Scope

The scope of this document is limited to the description of the core operational algorithm(s) required to create the CrIMSS AVTP, AVMP, and PP EDRs. The theoretical basis for this algorithm is described in Section 5.2 of the CrIS ATBD, D43772.

The CrIS ATBD includes a complete description of the science code methodologies for retrieving geophysical parameter profiles. It provides a retrieval scheme of geophysical parameter profiles from the combination of infrared (IR) and microwave (MW) spectral radiances. The retrieved profiles are comprised of atmospheric vertical temperature, moisture, and pressure profiles. An AVTP is a set of estimates of the average atmospheric temperature in three-dimensional cells centered on specific points along a local vertical. An AVMP is the same as AVTP, except that it pertains to average mixing ratio. A PP is a set of estimates of atmospheric pressure at specified altitudes above the Earth. The IR spectral radiances are contaminated by clouds; thus, improper scene classification could cause misclassification and induce large errors in the cloud-clear retrieval. See Section 5.2 of the CrIS ATBD for detailed information.

1.3 References

The primary software detailed design publications listed here include science software documents, NPOESS program documents, as well as source code and test data references.

1.3.1 Document References

The science and system engineering documents relevant to the algorithms described in this OAD are listed in Table 1.

Table 1. Reference Documents

Document Title	Document Number/Revision	Revision Date
Algorithm Theoretical Basis Document For the Cross Track Infrared Sounder (CrIS) Volume I, Sensor Data Records (SDR)	D43773 Rev. ---	6 Feb 2007
Algorithm Theoretical Basis Document For the Cross Track Infrared Sounder (CrIS) Volume II, Environmental Data Records (EDR)	D43772 Rev. B	7 Dec 2007
NPP EDR Production Report	D37005 Rev. C	16 Mar 2007
EDR Interdependency Report	D36385 Rev. C	7 Nov 2007
CDFCB-X Volume I - Overview	D34862-01 Rev. B	27 Aug 2007
CDFCB-X Volume II – RDR Formats	D34862-02 Rev. B	27 Aug 2007
CDFCB-X Volume III – SDR/TDR Formats	D34862-03 Rev. A	27 Aug 2007
CDFCB-X Volume IV Part 1 – IP/ARP/GEO Formats	D34862-04-01 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 2 – Atmospheric, Clouds, and Imagery EDRs	D34862-04-02 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 3 – Land and Ocean/Water EDRs	D34862-04-03 Rev. A	10 Sep 2007
CDFCB-X Volume IV Part 4 – Earth Radiation Budget EDRs	D34862-04-04 Rev. A	10 Sep 2007
CDFCB-X Volume V - Metadata	D34862-05 Rev. B	27 Aug 2007
CDFCB-X Volume VI – Ancillary Data, Auxiliary Data, Reports, and Messages	D34862-06 Rev. C	10 Sep 2007
CDFCB-X Volume VII – Application Packets	D34862-07 Rev. ---	10 Sep 2007
NPP Mission Data Format Control Book (MDFCB)	GSFC 429-05-02-42 R1	14 Apr 2006
NPP Command and Telemetry (C&T) Handbook	568423 Rev. A	5 Apr 2005
Operational Algorithm Description Document for the CrIS SDR software	D39132 Rev. B6	11 Apr 2008
Operational Algorithm Description Document for ATMS Resampling	D41883 Rev. A6	14 May 2008
Technical Memo – CrIMSS EDR Algorithm OAD Update	NP-EMD-2004.510-0048 Rev. ---	07 Nov 2004
Technical Memo – CrIMMSS EDR QF Update	NP-EMD.2005.510.0100 Rev. ---	25 Aug 2005
Technical Memo – CrIMSS Drop 2.1.2 OAD Updates	NP-EMD.2007.510.0015 Rev. ---	15 Feb 2007
Technical Memo – CrIMSS QF Memo	NP-EMD.2005.510.0029 Rev. ---	2 Mar 2005
Technical Memo – MEMO_CrIMSS_LATENCY_TRADES	NP-EMD.2005.510.0030 Rev. ---	3 Mar 2005
Susskind and Joiner, (TBS01)	(TBS01)	1993
NPOESS Calibration/Validation Plan	D34484 Ver. 3.0	17 Dec 2002
NPOESS EDR Performance Report	NPOESS.02.520.010 Ver. 3.3	2 Feb 2002
NPOESS EDR Synergisms and Fusion Summary	D34837 Rev. ---	20 Feb 2002
NPOESS IDP Segment Central Specification	SY10-0003 Rev. E	1 Aug 2002
NPOESS Modeling and Simulation Plan	D34475 Ver. 1.0	15 Mar 2002
NPOESS Scene Generation Development Report	D34861 Ver. 1.0	11 Feb 2002

Document Title	Document Number/Revision	Revision Date
NPOESS Software Development Plan	D31417 Ver. E	21 Oct 2002
NPOESS Subcontract Management Plan	D34845 Ver. 1.0	18 Feb 2002
NPOESS System Specification	SY15-0007 Ver. E	1 Aug 2002
NPOESS System Test Plan	D31406 Ver. 1.0	23 Sep 2002
Data Processor Inter-subsystem Interface Control Document (DPIS ICD)	D35850 Rev. U	23 Jan 2008
D35836_E_NPOESS_Glossary	D35836_E Rev. E	23 May 2005
D35838_E_NPOESS_Acronyms	D35838_E Rev. E	23 May 2005

1.3.2 Source Code References

The science and operational code and associated documentation relevant to the algorithms described in this OAD are listed in Table 2.

Table 2. Source Code References

Reference Title	Reference Tag/Revision	Revision Date
Science Code Documentation for the Cross Track Infrared Sounder (CrIS) Environmental Data Records (EDR), Volume I	P1196-TR-I-4.0-SC-CODE-DOC-01-04, Ver. 4.0	Jan 2004
Science Code Documentation for the Cross Track Infrared Sounder (CrIS) Environmental Data Records (EDR), Volume II	P1196-TR-I-4.0-SC-CODE-DOC-01-04, Ver. 4.0	Jan 2004
Science code drop by NGST	ISTN_CRIMSS_EDR_2.1	30 Apr 2004
UT data drop by NGST	ISTN_CRIMSS_EDR_2.1	30 Apr 2004
CrIMSS EDR operational code	CrIMSS EDR Build 1.5	Jun 2007
Science code drop by NGST	ISTN_CRIMSS_EDR_2.1.1	23 Nov 2004
Science code drop by NGST	ISTN_CRIMSS_EDR_2.1.2	30 Mar 2007

2.0 ALGORITHM OVERVIEW

This document details the operational algorithm description of the CrIMSS EDR retrieval code, which produces the AVTP, AVMP, and PP EDRs. Most of the signal reaching satellite-based infrared (IR) and microwave (MW) wavelength detectors above the land and ocean is of atmospheric emission, surface or cloud emission, and reflection. The core of the CrIMSS software is the retrieval module. The Fortran retrieval algorithm is followed by a C++ module which converts the retrieval information at Optimal Spectral Sampling (OSS) levels to layer data at the EDR output product specifications. Configurable parameters used for tuning are read from the Data Management Subsystem (DMS). Figure 1 illustrates the structure of the major modules and general flow control of the modules.

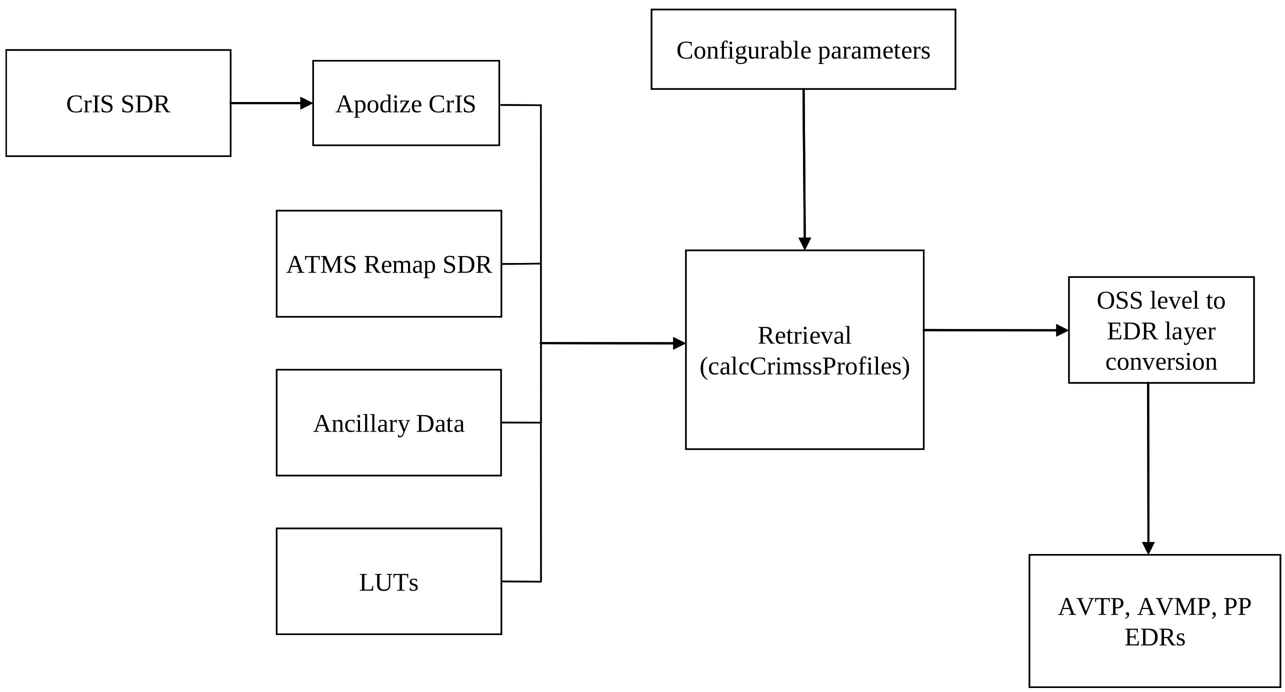

Figure 1. Main Module Diagram

Inputs to the algorithm are measured CrIMSS spectral radiances in the IR and MW bands, and external data when MW sounder data is unavailable. Required external data in case of MW instruments failure include CMIS temperature and humidity EDRs used as an initial guess for the IR retrieval (currently not implemented in the code). If CMIS is unavailable, first guess fields are generated using data from a Numerical Weather Prediction (NWP) model. Surface pressure is always obtained from NWP data.

2.1 CrIMSS EDR Description

The mission of the Crosstrack Infrared and Microwave Sounding Suite (CrIMSS) is to produce both Sensor Data Record (SDR) and EDR in support of the NPOESS mission requirements. The Crosstrack Infrared Sounder (CrIS) collects upwelling infrared spectra and is used with microwave data to construct temperature, moisture, and pressure profiles of the earth's atmosphere. Collectively, the CrIS and microwave sensor are referred to as CrIMSS.

2.1.1 Interfaces

To begin data processing, the Infrastructure (INF) Subsystem Software Item (SI) initiates the CrIMSS algorithm. The INF SI provides tasking information to the algorithm indicating which granule to process. The Data Management Subsystem (DMS) SI provides data storage and retrieval capability.

The CrIMSS config guide (xml) specifies shortnames within DMS of input and output data used by the CrIMSS EDR algorithm. The shortnames used in this file are included in Tables 3 through 5.

2.1.1.1 Inputs

Implementation of the CrIMSS retrieval algorithm requires the CrIS SDR, ATMS resampled SDR, as well as ancillary and auxiliary data to retrieve AVTP, AVMP, and PP EDRs. General descriptions of all input data are found in Table 3. Refer to the DPIS ICD for a detailed description of the inputs.

Table 3. CrIMSS EDR Retrieval Algorithm Inputs

Input	Short Name	Description
CrIS SDR	CrIS-SDR	CrIS radiances for each CrIS Field of View (FOV) location. Includes channel frequencies.
CrIS GEO data	CrIS-SDR-GEO	CrIS geolocation information including lat/lon, sun zenith angles, and sensor zenith angles for each CrIS FOV location.
ATMS Remap SDR	ATMS-REMAP-SDR	ATMS brightness temperatures resampled to the center CrIS FOV.
Ancillary Land Fraction Data	Land-Frac-ANC-CRIS-Gran	Land fraction at each CrIS FOV location.
NWP Surface Pressure data	NCEP-Press-Surf-ANC-CrIS-Gran	Surface Pressure at each CrIS FOV location from NWP data.
CrIMSS Channel Selection LUT	CrIMSS-CHAN-SEL-LUT	Flags indicating which channels are to be used in the retrievals.
CrIMSS IR Noise	CrIMSS-IR-NOISE-LUT	CrIS NEdN(noise) data.
CrIMSS MW Noise	CrIMSS-MW-NOISE-LUT	MW noise data.
CrIMSS Climate Data	CrIMSS-CLIM-LUT	Climatological means for error covariance, eigenvectors and background profiles for eight stratified environmental conditions.
CrIMSS Surface Emissivity	CrIMSS-SFC-EMIS-LUT	IR surface emissivity hinge points for the retrieval.
CrIMSS Solar Data	CrIMSS-SOLAR-LUT	Solar irradiance and IR frequency data.
CrIMSS Day LAA Coefficients	CrIMSS-DAY-LAA-COEFF-LUT	Regression coefficients used for daytime local angle adjustment of the FOV radiances.
CrIMSS Night LAA Coefficients	CrIMSS-NIGHT-LAA-COEFF-LUT	Regression coefficients used for nighttime local angle adjustment of the FOV radiances.
CrIMSS MW Frequency and Polarization	CrIMSS-MW-FRQ-POL-LUT	MW frequency, weights, and polarization information.
CrIMSS Day LAA EOF	CrIMSS-DAY-LAA-EOF-LUT	EOFs used for the daytime local

Input	Short Name	Description
		angle adjustment of the CrIS FOVs.
CrIMSS Night LAA EOF	CrIMSS-NIGHT-LAA-EOF-LUT	EOFs used for the nighttime local angle adjustment of the CrIS FOVs.
CrIMSS MW OSS Coefficients	CrIMSS-MW-OSS-COEFF-LUT	MW OSS coefficient and channel information data (used by the OSS model).
CrIMSS IR OSS Coefficients	CrIMSS-IR-OSS-COEFF-LUT	IR OSS coefficient and channel information data (used by the OSS model).
CrIMSS MW Absorption Coefficients	CrIMSS-MW-ABSORP-COEFF-LUT	MW absorption coefficients at OSS levels as well as temperature and water vapor data.
CrIMSS IR Absorption Coefficients	CrIMSS-IR-ABSORP-COEFF-LUT	IR absorption coefficients at OSS levels as well as temperature and water vapor data.
CrIMSS MW Noise Amplification Factor	CrIMSS-MW-NOISE-AMPL-LUT	MW noise amplification factor data.
CrIMSS Configurable parameters	CrIMSS-EDR-AC-Int	Configurable parameters used by the CrIMSS EDR processing code.
CrIMSS IR Channel Atmospheric Noise	CrIMSS-IR-ATM-NOISE-LUT	Atmospheric noise for the IR channels.
CrIMSS MW Channel Atmospheric Noise	CrIMSS-MW-ATM-NOISE-LUT	Atmospheric noise for the MW channels.
CrIMSS Trace Gas Reference Profiles	CrIMSS-TRACE-GAS-LUT	Trace gas reference profiles.
CrIMSS Above Tropopause Reference Profiles	CrIMSS-TROP-LUT	Reference profiles used to adjust the standard profiles from the tropopause to the top of the atmosphere.
NWP Surface Geopotential Height	NCEP-Geopot-Ht-Surf-ANC-CrIS-Gran	NWP geopotential height of the surface. Used in the adjustment of the surface pressure.
Terrain Height	USGS-GTOPO30-Surf-Ht-ANC-CrIS-Gran	Terrain height from digital elevation map (DEM). Used in the adjustment of the surface pressure.
NWP Temperature at Pressure Levels	NCEP-Iso-Lev-Temp-ANC-CrIS-Gran	NWP temperature at pressure levels. Used in the adjustment of the surface pressure and used to generate the first guess if MW data is not available.
NWP Mixing Ratio at Pressure Levels	NCEP-Mix-Rat-Press-Lev-ANC-CrIS-Gran	NWP mixing ratio at pressure levels. Used in the adjustment of the surface pressure and used to generate the first guess if MW data is not available.
NWP Surface Temperature	NCEP-Temp-Surf-ANC-CrIS-Gran	NWP surface temperature. Used for the first guess skin temperature if MW data is not available.
NWP to CrIMSS Conversion Coefficients for Temperature	CrIMSS-NWP-TEMP-COEFF-LUT	Coefficients used to convert temperature from the NWP levels to the levels used in the CrIMSS EDR algorithm. Only used if MW data is

Input	Short Name	Description
		not available.
NWP to CrIMSS Conversion Coefficients for Water Vapor	CrIMSS-NWP-WAT-VAP-COEFF-LUT	Coefficients used to convert water vapor from the NWP levels to the levels used in the CrIMSS EDR algorithm. Only used if MW data is not available.
CrIMSS EDR DQN Threshold Table	CrIMSS-EDR-DQTT-Int	Contains test criteria needed to determine whether a Data Quality Notification should be stored to DMS.
CrIMSS IR Ozone IP DQN Threshold Table	CrIS-IR-OZ-Prof-IP-DQTT-Int	Contains test criteria needed to determine whether a Data Quality Notification should be stored to DMS.

2.1.1.2 Outputs

The CrIMSS EDR algorithm software produces one EDR product output that contains the AVMP EDR, AVTP EDR, and PP EDR data along with quality flag data. EDR data values for layers extending below ground are set to the NA_FLOAT32_FILL value. Table 6 shows the reporting pressure levels and vertical cell size of the AVTP and AVMP EDRs and the reporting altitudes of the PP EDR as well as the corresponding index in the output array. The algorithm also produces an EDR GEO product that contains the geolocation information for each retrieval.

There are also nine IP products. The temperature, moisture and ozone profiles are output at the 101 OSS levels. The pressure of each of the 101 levels is shown in Table 7.

Table 4. CrIMSS EDR Output Data

Output	Object format	Short Name	Description
CrIMSS EDR	IDPS internal format	CrIMSS-EDR	Contains the AVTP, AVMP, PP EDR data as well as auxiliary data AVTP EDR data: Atmospheric vertical temperature profile EDR which consists of vertically averaged atmospheric temperature (K) for 42 layers. AVMP EDR data: Atmospheric vertical moisture profile EDR which consists of vertically averaged atmospheric water mass mixing ratios (g/kg) for 22 layers. PP EDR data: Atmospheric vertical pressure profile EDR which consists of atmospheric pressure at 31 altitudes. (hPa) Auxiliary data: Data associated with the each retrieval including retrieval FOR number, land fraction, surface Pressure, and quality information. Also includes granule quality flags.

Output	Object format	Short Name	Description
CrIMSS EDR GEO TC	IDPS internal format	CrIMSS-EDR-GEO-TC	CrIMSS terrain-corrected geolocation information including lat/lon, sun zenith angles, and sensor zenith angles.

Table 5. CrIMSS IP Output Data

Output	Object format	Short Name	Description
AVTP Level IP	IDPS internal format	CrIMSS-CrIS-AVTP-LOS-IR-IP	Second stage (MW + IR) temperature retrieval data at the OSS levels. (K)
AVMP Level IP	IDPS internal format	CrIMSS-CrIS-AVMP-LOS-IR-IP	Second stage (MW + IR) moisture retrieval data at the OSS levels. (g/kg)
AVTP MW Level IP	IDPS internal format	CrIMSS-CrIS-AVTP-LOS-MW-IP	First stage temperature retrieval data at the OSS levels. (K) (Contains the NWP derived guess at OSS levels if MW data is not available.)
AVMP MW Level IP	IDPS internal format	CrIMSS-CrIS-AVMP-LOS-MW-IP	First stage moisture retrieval data at the OSS levels. (g/kg) (Contains the NWP derived guess at OSS levels if MW data is not available.)
IR Surface Emissivity IP	IDPS internal format	CrIMSS-CrIS-IR-SURF-EMISSIVITY-IP	IR surface emissivity at the surface emissivity hinge points.
Ozone IP	IDPS internal format	CrIMSS-IR-OZ-Prof-IP	Retrieved ozone profile at the OSS levels. (ppmv)
CrIS Cloud Cleared Radiance IP	IDPS internal format	CrIMSS-CrIS-CLOUD-CLEARED-RAD-IP	Cloud cleared CrIS radiances. (mw/m2/str/cm-1)
MW Surface Emissivity IP	IDPS internal format	CrIMSS-CrIS-MW-SURF-EMISSIVITY-IP	MW surface emissivity for each of the ATMS channels.
Skin Temperature IP	IDPS internal format	CrIMSS-CrIS-SKIN-TEMP-IP	Skin temperature retrieval data (K)

Table 6. Reporting Pressure Levels and Vertical Cell Size of AVTP and AVMP EDRs and Reporting Altitudes of PP EDR

Level	AVTP Reporting Pressure (hPa)	AVTP Reporting Cell Size (km)	AVMP Reporting Pressure (hPa)	AVMP Reporting Cell Size (km)	PP Reporting Altitude (km)
1	0.5	5	100	2	30
2	0.7	5	150	2	29
3	0.9	5	200	2	28
4	1	5	250	2	27

Level	AVTP Reporting Pressure (hPa)	AVTP Reporting Cell Size (km)	AVMP Reporting Pressure (hPa)	AVMP Reporting Cell Size (km)	PP Reporting Altitude (km)
5	3	5	300	2	26
6	5	5	350	2	25
7	7	5	400	2	24
8	9	5	450	2	23
9	10	5	500	2	22
10	30	3	550	2	21
11	50	3	600	2	20
12	70	3	650	2	19
13	90	3	700	2	18
14	100	3	750	2	17
15	125	3	800	2	16
16	150	3	850	2	15
17	175	3	870	2	14
18	200	3	890	2	13
19	225	3	910	2	12
20	250	3	930	2	11
21	275	3	950	2	10
22	300	1	970	2	9
23	350	1	---	---	8
24	400	1	---	---	7
25	450	1	---	---	6
26	500	1	---	---	5
27	550	1	---	---	4
28	600	1	---	---	3
29	650	1	---	---	2
30	700	1	---	---	1
31	750	1	---	---	0
32	800	1	---	---	---
33	850	1	---	---	---
34	870	1	---	---	---
35	890	1	---	---	---
36	900	1	---	---	---
37	920	1	---	---	---
38	940	1	---	---	---

Level	AVTP Reporting Pressure (hPa)	AVTP Reporting Cell Size (km)	AVMP Reporting Pressure (hPa)	AVMP Reporting Cell Size (km)	PP Reporting Altitude (km)
39	960	1	---	---	---
40	980	1	---	---	---
41	1000	1	---	---	---
42	1020	1	---	---	---

Table 7. OSS Pressure Levels

Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)
1	4.9999E-03	2	1.61E-02	3	3.84E-02	4	7.68998E-02
5	0.137	6	0.2244	7	0.3454	8	0.5064
9	0.714	10	0.9753	11	1.2972	12	1.6872
13	2.1526	14	2.7009	15	3.3398	16	4.077
17	4.9204	18	5.8776	19	6.9567	20	8.1655
21	9.5119	22	11.004	23	12.649	24	14.456
25	16.432	26	18.585	27	20.922	28	23.453
29	26.183	30	29.121	31	32.274	32	35.650
33	39.257	34	43.1	35	47.188	36	51.528
37	56.126	38	60.989	39	66.125	40	71.54
41	77.24	42	83.231	43	89.52	44	96.114
45	103.02	46	110.24	47	117.78	48	125.65
49	133.85	50	142.38	51	151.27	52	160.5
53	170.08	54	180.02	55	190.32	56	200.99
57	212.03	58	223.44	59	235.23	60	247.41
61	259.97	62	272.92	63	286.26	64	300.
65	314.14	66	328.67	67	343.62	68	358.97
69	374.72	70	390.89	71	407.47	72	424.47
73	441.88	74	459.71	75	477.96	76	496.63
77	515.72	78	535.23	79	555.17	80	575.53
81	596.31	82	617.51	83	639.14	84	661.19
85	683.67	86	706.57	87	729.89	88	753.63
89	777.79	90	802.37	91	827.37	92	852.79
93	878.62	94	904.87	95	931.52	96	958.59

Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)	Level	Pressure (hPa)
97	986.07	98	1014.0	99	1042.2	100	1070.9
101	1100.	---	---	---	---	---	---

2.1.2 Algorithm Processing

The CrIMSS retrieves AVTP, AVMP, and PP EDRs from the signals received at the satellite-based IR and MW wavelength detectors. Inputs to the algorithm are measured Top of Atmosphere (TOA) spectral radiances in the IR and MW bands. If MW data is not available then NWP model data is used to produce the first guess. The core of the CrIMSS software is the retrieval module. The retrieval module produces temperature and moisture profiles at the OSS levels. Conversion of the level data to layers is done after all of the retrievals have been generated. Figure 2 illustrates the top-level flow diagram for the CrIMSS retrieval algorithm. The algorithm consists of these tasks:

- Preprocess CrIS data
- Initialization
- Input and pre-processing
- Microwave-only retrieval
- Scene classification
- Joint microwave and infrared retrieval
- Quality control and output
- Post-processing

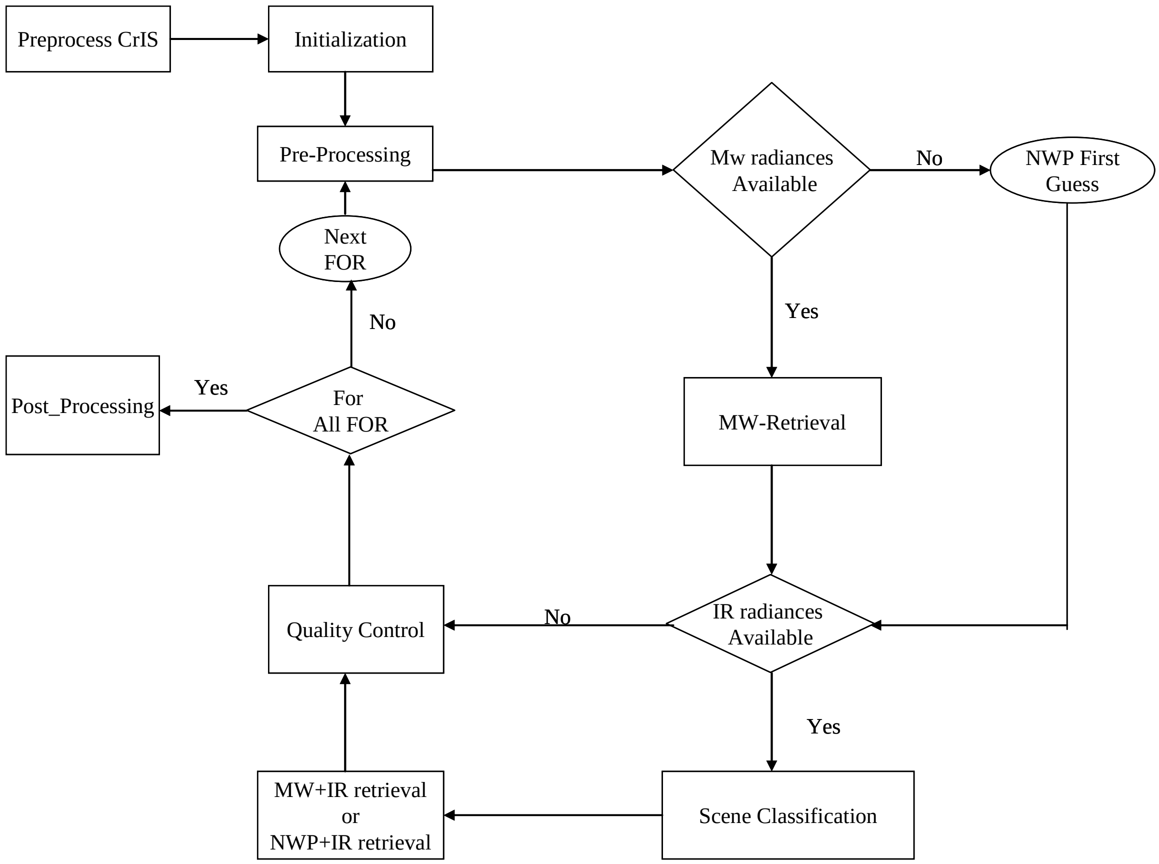

Figure 2. CrIMSS EDR Algorithm Flow Diagram

2.1.2.1 Main Module - ProEdrCrimssAtmProf (ProEdrCrimssAtmProf.cpp)

This is the derived algorithm class for the CrIMSS algorithm and is a subclass of the ProCmnAlgorithm class. ProEdrCrimssAtmProf reads all data items required by the algorithm from DMS and passes the data into the algorithm. Since the number of retrievals that the algorithm produces can vary, the size of the EDRs is determined after the main algorithm routine completes. Before the CrIS radiances are passed into the main Fortran algorithm, apodization is applied. After the main algorithm routine (calcCrimssProfiles) completes, the status returned from the algorithm is checked and, if the algorithm did not complete successfully, the derived algorithm sends status to Infrastructure that the EDR was not generated successfully via the common code. If the algorithm completed successfully, the retrieval data at the OSS levels is converted to layer data at the layers specified for the EDRs.

2.1.2.2 Preprocess CrIS

The CrIS SDR algorithm produces unapodized radiances. Before the CrIS radiances are passed into calcCrimssProfiles, apodization is applied. Apodization was originally performed in the CrIS SDR algorithm science code. Apodization was moved to the CrIMSS EDR code rather than having the CrIS SDR algorithm produce both an apodized and unapodized product. After apodization, the longwave, midwave, and shortwave radiances are concatenated in one radiance vector for use in the calcCrimssProfiles routine. Also, GEO data such as zenith angles and lat/lons as well as quality data needed by the algorithm are stored in a structure for use in calcCrimssProfiles. Figure 3 shows the software components of Preprocess CrIS.

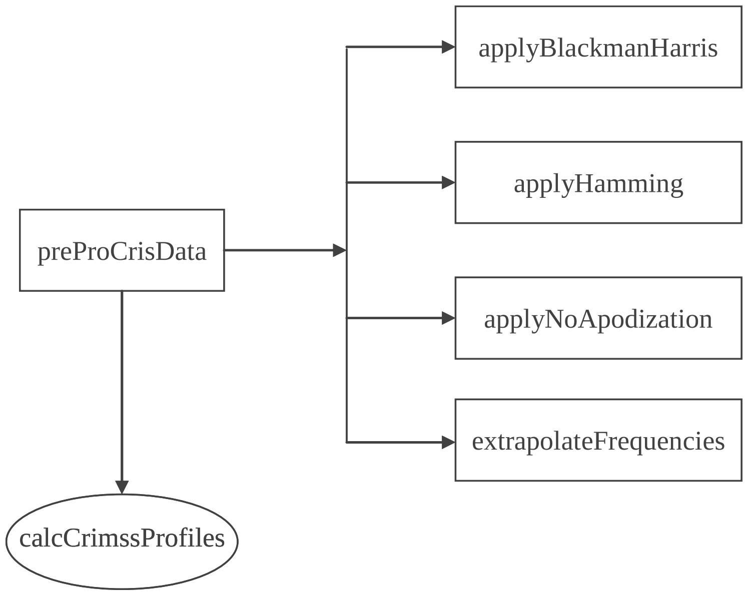

Figure 3. Software Components of Preprocess CrIS

2.1.2.2.1 preProCrisData (proEdrCrimssAtmProf.cpp)

This module reads CrIS SDR data and stores the SDR data needed during algorithm processing to a structure which is accessed by the Fortran routines. The routine applies apodization to the radiances produced by the CrIS SDR algorithm. In the case where no CrIS SDR data is available, and MW only retrievals are to be produced, the routine only stores CrIS SDR GEO data to the internal structure.

The CrIS SDR algorithm produces unapodized radiances. CrIMSS currently allows three choices for apodization type: Blackman-Harris, Hamming, and None. This routine calls applyBlackmanHarris, applyHamming, or applyNoApodization depending on the apodization choice. The apodized CrIS radiances are then stored in an intermediate structure (CrisApodSdrDataType) to be used in calcCrimssProfiles. The type of apodization to apply is specified in the run-time adjustable parameters in the apodFlag field.

Each type of apodization can be characterized as a sliding window over the unapodized radiance vectors from the CrIS SDR. Application of apodization results in a vector, four bins shorter than the SDR input (two are clipped from the beginning and end of the CrIS band data). When None is chosen the radiances are not modified, but the first and last two values are clipped from the SDR input. Figure 4 shows the action of applying Hamming apodization to an input vector. Above is the input vector with an arrow showing the motion of the sliding window. Below, is the resulting vector. Note that the sliding window is in the position which calculates the value of the resulting vector.

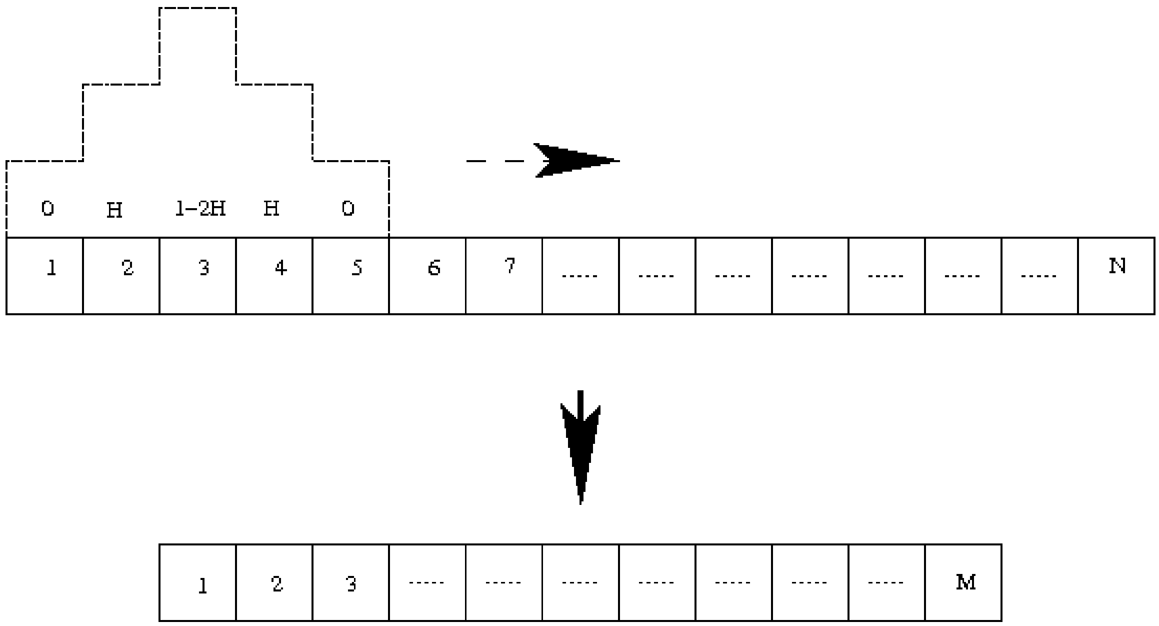

Figure 4. Hamming Apodization

Hamming apodization is implemented as a weighted average of three contiguous array values and Blackman-Harris apodization is implemented as a weighted average of five contiguous array values. The formulae for each type of apodization are:

Hamming:

$$x_{i-2} = Hy_{i-1} + (1-2H)y_i + Hy_{i+1}$$

Blackman-Harris:

$$x_{i-2} = \frac{B_2}{2} y_{i-2} + \frac{B_1}{2} y_{i-1} + B_0 y_i + \frac{B_1}{2} y_{i+1} + \frac{B_2}{2} y_{i+2}$$

None:

$$x_{i-2} = y_i$$

for $i \in 3 \ldots M$ where *M* is the length of the resulting vector, H (0.23) is the constant for the Hamming window and, B_0 (0.42323), B_1 (0.49755), and B_2 (0.07922) are the constants for the Blackman-Harris window.

Apodization is applied for each of the CrIS bands and the channels of the three bands are concatenated (long wave+mid-wave+shortwave=1305 channels) before being passed into the algorithm, since the algorithm uses them as a single vector.

2.1.2.2.2 extrapolateFrequencies (proEdrCrimssAtmProf.cpp)

Given a starting frequency and delta from the CrIS SDR data, this routine generates the frequencies for all channels in a CrIS band. The frequencies are passed into calcCrimssProfiles.

2.1.2.2.3 applyBlackmanHarris (proEdrCrimssAtmProf.cpp)

This routine applies Blackman-Harris apodization to the CrIS SDR radiances.

2.1.2.2.4 applyHamming (proEdrCrimssAtmProf.cpp)

This routine applies Hamming apodization to the CrIS SDR radiances.

2.1.2.3 Main Algorithm Routine (calcCrimssProfiles.f)

The main algorithm routine calcCrimssProfiles is called from the derived algorithm class ProEdrCrimssAtmProf (from the doProcessing method) to create the CrIMSS retrieval profiles at OSS levels. Access to input data from DMS is provided through pointers in the CRIMSS_ALG_DATA_TYPE structure. This structure also contains a pointer (crimssRetrLvlDataPtr) to the structure where the retrieval data is written. This structure is used by the derived algorithm to access the retrieval level data. The calcCrimssProfiles routine checks for a stop callback issued from Infrastructure after a Field of Regard (FOR) has been processed. When a stop callback is detected, the appropriate status is passed back to the calling routine (ProEdrCrimssAtmProf::doProcessing). When the calcCrimssProfiles routine completes, it returns the status of the algorithm processing back to the calling routine (ProEdrCrimssAtmProf::doProcessing).

2.1.2.3.1 Fortran Global Data

Fortran modules are used to hold globally available data and variables needed to run the CrIMSS retrieval code.

2.1.2.3.1.1 crims (crims.f)

This module is used in the major components of the CrIMSS algorithm. It has the upper limits for the number of channels, number of cloud formations, cloud hinge points, number of cloud retrievals, number of FOVs, and MW data availability flag. It also contains the variables used for the frequency, emissivity and reflectivity indexing at the surface and cloud levels, and the hinge frequencies for the first guess.

2.1.2.3.1.2 prof_index (prof_index.f)

The vector concept is implemented in the geophysical domain. The geophysical parameters are bundled together and indexed consistently with lengths defined in the **input_desc** module. The indices are adjusted automatically once the lengths are determined. Unless the structure of the retrieval profile is changed the assignments in this module need not be altered.

2.1.2.3.1.3 input_desc (input_desc.f)

This module defines the parameter lengths for mapping the profiles for the forward and the inversion processes, as well as the indexing in the inversion process. This module is used mainly by the **prof_index** module. The variables are specified according to the convention, "prefix"+"physical meaning"+"suffix", where prefix is either "n", for length, or "i", for index. The suffix is either with or without "g", which represent geophysical domain or retrieval domain, respectively. The physical meanings of the variables are defined as follows. The dimensions are defined as, nparmw=total number of elements in the MW retrieval vector, npar=total number of elements in the IR retrieval vector, nlev=number of standard vertical levels, and nlay=number of standard vertical layers.

2.1.2.3.1.4 rt_ir (rt_ir.f)

This module contains parameters, variables, and arrays used by the OSS IR routines.

2.1.2.3.1.5 rt_mw (rt_mw.f)

This module contains parameters, variables, and arrays used by the OSS MW routines.

2.1.2.3.1.6 database (database.f)

This module defines the arrays for background profile, covariance, and covariance conversion matrices between the geophysical and the retrieval domains.

2.1.2.3.1.7 ossdrv (ossdrv.f)

This module is used for passing selection flags for trace gases and the pressure grid. The selection vector is initialized in setIprof.f. The pressure grid is defined in this module.

2.1.2.3.1.8 crimss_constants (crimss_constants.f)

This module defines constants used in the CriMSS algorithm Fortran routines. Constants include dimensions of fields in the input and output data structures and variable initialization values.

2.1.2.3.1.9 crimss_interfaces (crimss_interfaces.f)

This module provides explicit interfaces for the CrIMSS algorithm subroutines. This allows compile time checking of subroutine arguments.

2.1.2.3.1.10 crimss_struct (crimss_struct.f)

This module defines the input data structures used for CrIMSS EDR processing. The structures here should mirror the structures contained in the ProEdrCrimssStruct.h file.

2.1.2.3.1.11 debug (debug.f)

This module contains flags and variables used for providing debug output as well as subroutines for outputting debug print-a-line-at-a-time or a-page-(i.e. multiple lines) at-a-time. Subroutine printLine sends a line of output to the INF debug utility. Subroutine addLine adds a line to the debug page buffer. Subroutine printPage prints the contents of the page buffer to the INF debug utility. The purpose of this module is to reformat the output lines slightly and allow output to be sent to debug a line at a time or a page at a time so it can be read easier when debug is output to the screen.

2.1.2.3.2 CrIMSS EDR Components

The CrIMSS EDR algorithm consists of seven components: initialization, input and pre-processing, MW-only retrieval, scene classification, joint MW and IR retrieval, QC, output and post-processing.

2.1.2.4 Initialization

A detailed description of the initialization model is given in the CrIS ATBD, Section 5.1. During initialization, various static data (i.e., data not updated on a regular basis) are accessed by the algorithm. A graphical presentation of the module and the functional description of its components are given in Figure 5.

Overview:

Associate pointers to input data in DMS which are passed in by the derived algorithm (C++ code) to pointers used by the calcCrimssProfiles routine to access the DMS data.

Initialize debug output parameters to enable output to Infrastructure debug utility and output adjustable parameter values (only if debug is set to 'on').

Set indices in determining how the trace gases are handled by the forward model. For a particular trace gas, its mixing ratio profile can be fixed to that of the standard, or be calculated by scaling a particular profile with a constant scaling factor, or be varied at each atmospheric pressure level.

Load OSS forward model parameters, optical depth tables and instrument specifications.

Load pre-calculated background error covariance matrices for different atmospheric and surface conditions.

Compute IR emissivity and reflectivity interpolation coefficients at pre-selected hinge points. These coefficients are used to convert emssivities/reflectivities and their associated derivatives from the CrIS channel frequency grid to pre-defined hinge points.

Initialize channel indices for the cloud clearing calculation. This is done for computational efficiency.

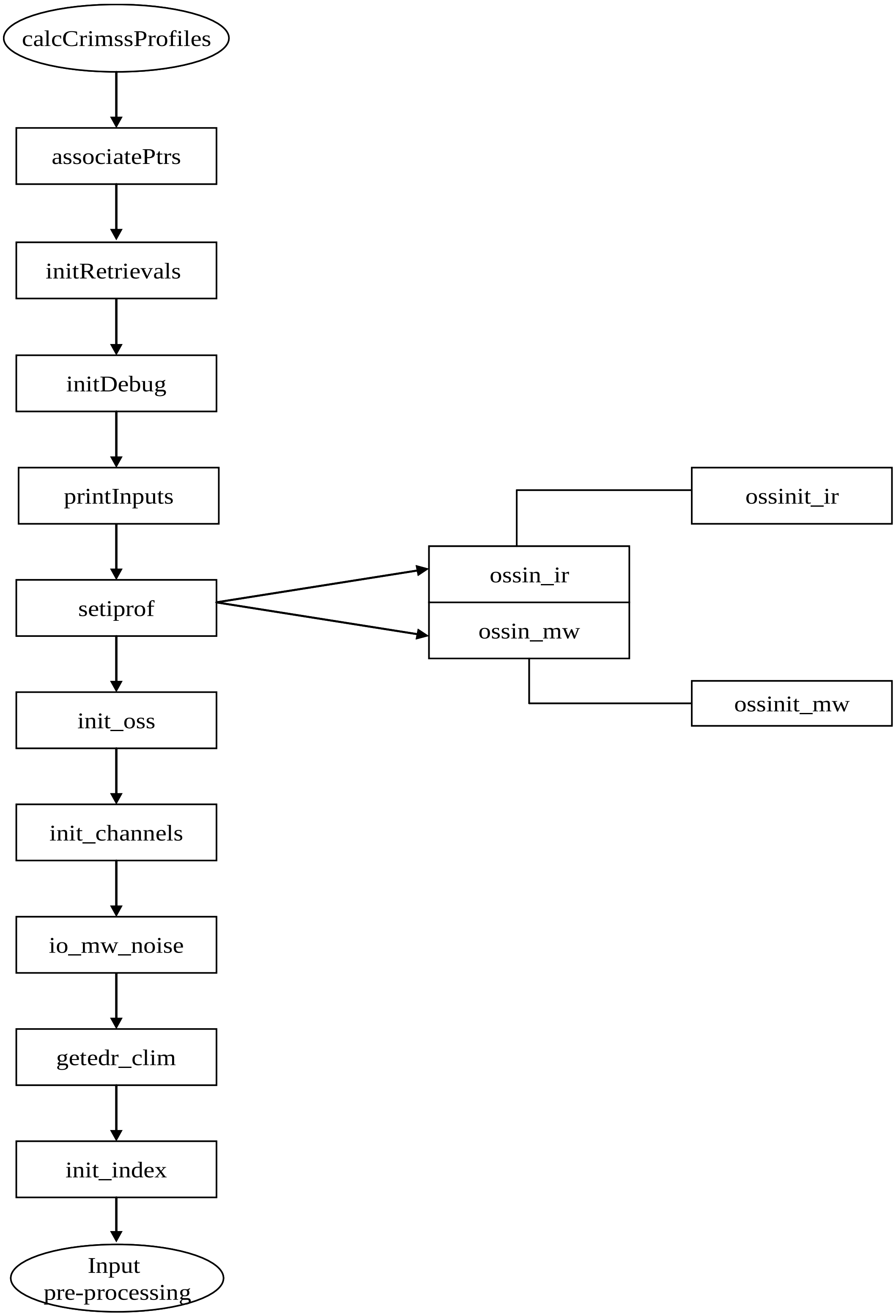

Figure 5. Software Components of Initialization

2.1.2.4.1 associatePtrs (crimss_struct.f)

This routine associates data pointers used by the CrIMSS algorithm with input data passed in from DMS prior to the processing.

2.1.2.4.2 initRetrievals (putRetInfo.f)

This routine initializes buffers in the retrieval intermediate structure to fill values. The structure contains fields for all retrieval information which are output to DMS after processing is completed. If a field for a given retrieval is not updated during processing, it contains the fill value.

2.1.2.4.3 initDebug (debug.f)

This routine initializes the buffer used to hold output to the Infrastructure debug utility and sets the debug write flag according to value of the debug flag read from DMS.

2.1.2.4.4 printInputs (printinputs.f)

This routine outputs the values of the configurable input parameters which were read from DMS if the write debug flag is set true.

2.1.2.4.5 setiprof (setIprof.f)

This function defines flags for the treatment of trace gases in the forward model:

iprof=0: the reference profile contained in the optical depth file is used

Iprof=1: the reference profile contained in the optical depth file is multiplied by a constant factor, and

Iprof=2: user-supplied or retrieved profile is used (this option is always used for H_2O).

The flags are determined based on the number of parameters for the gas in the geophysical domain [e.g., for N2O: nn2og=1 corresponds to iprof(4)=1] and are passed via the prof_index module. The trace gases include H_2O, CO_2, O_3, N_2O, CO, and CH_4 and are indexed using their HITRAN indices.

2.1.2.4.6 init_oss (initoss.f)

This routine loads the IR and MW optical depth tables.

2.1.2.4.7 ossin_ir (ossin_ir.f)

This routine loads parameters for the OSS model in the IR including reference atmospheric profiles, OSS coefficients, and optical depth tables. The "fixed gas" optical depths are computed dynamically depending on the selection of variable gases.

2.1.2.4.8 ossin_mw (ossin_mw.f)

This routine loads parameters for the OSS model in the MW including reference atmospheric profiles, OSS coefficients, and optical depth tables. MW channel frequencies are also read here.

2.1.2.4.9 init_channels (initChSy.f)

This routine does channel initialization. The IR channel selection flags are read from DMS, but are reset here depending on the channel frequency. The MW channel selection flags are set according to selection flag data read from the configurable parameter data in DMS.

2.1.2.4.10 io_mw_noise (io_mw_noise.f)

This routine loads MW NEdT data and computes the root mean square (RMS) of NEdT. A vector of MW and IR frequencies updated with MW NedT values, RMS of MW NedT and the NedT noise vector is output by this routine.

2.1.2.4.11 getedr_clim (getEDR_clim.f)

This routine loads climatological means, error covariance, and eigenvectors for a given stratification type (stratified by land type).

2.1.2.4.12 init_indx (calc_cc_rad.f)

This routine initializes the index array used in calc_cc_rad_cor routine.

2.1.2.4.13 set_atmnoisebt (calcCrimmsProfiles.f)

This routine loads MW & IR noise from data stored in DMS.

2.1.2.4.14 sdrlaa (sdrlaa.f)

The nine FOVs within an FOR are observed with slightly different scan angles. A set of regression coefficients are applied to the radiances in eight of the nine FOVs projected onto a set of eigenfunctions in order to determine the radiance correction relative to the central FOV.

2.1.2.5 Input and Pre-processing

A description of this module is given in the CrIS ATBD, Section 5.2. This section of the code reads in the SDR input data. Precipitation screening and surface type determination are performed as well. In the current version, the surface type (ocean or land) is determined solely from the land fraction. Based on the surface type, the appropriate background covariance matrix is assigned. Surface pressure is computed using NWP fields. Figure 6 shows the structure of the input and pre-processing module in a graphical form.

Overview of input and pre-processing:

Read the MW and IR SDR data.

Calculate scene-dependent IR instrument NEdN.

Assign global background and covariance, depending upon surface type (ocean or land).

Calculate surface pressure from NWP fields.

If MW data is unavailable, construct the first guess using NWP temperature and moisture fields.

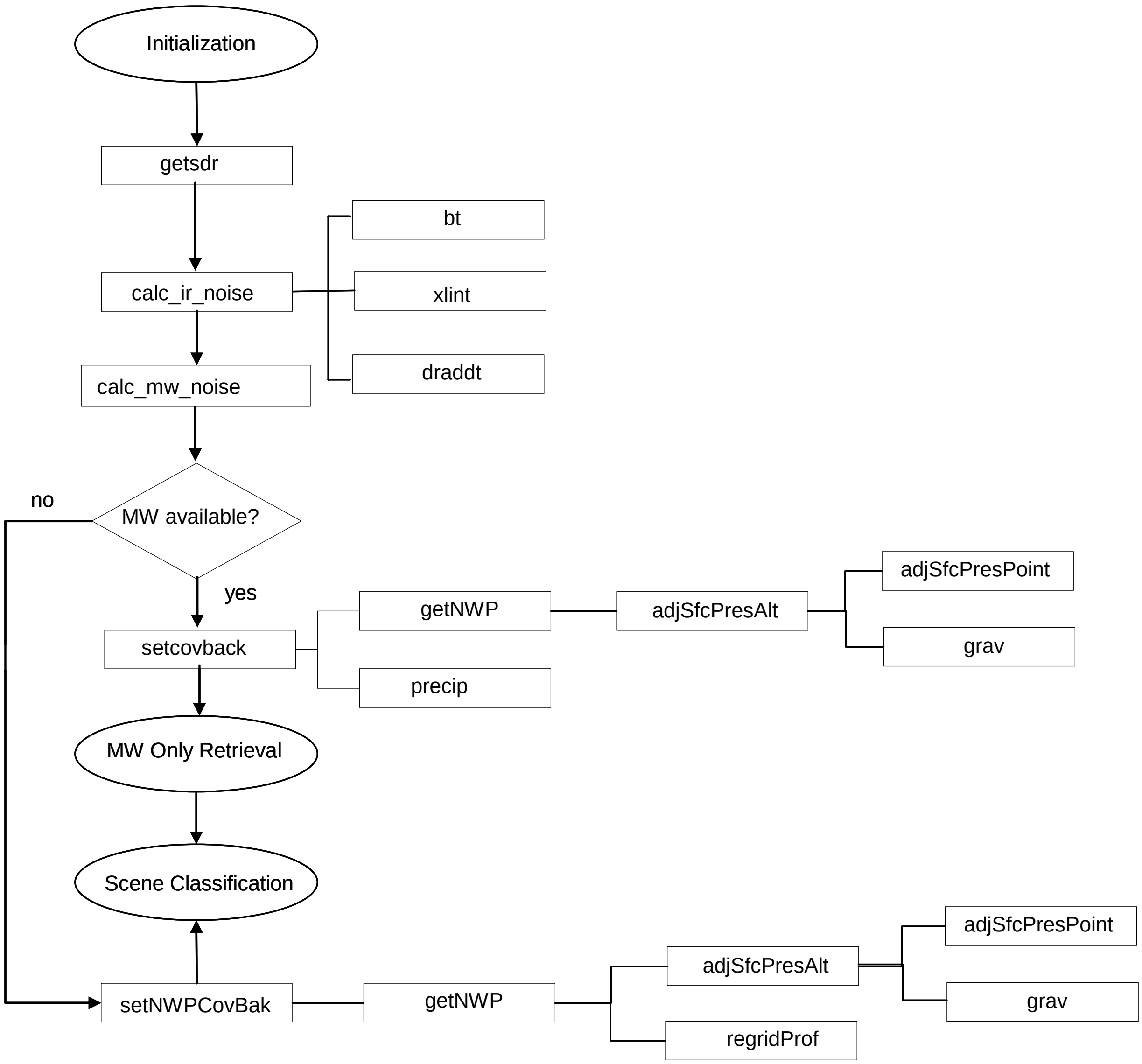

Figure 6. Software Components of Input and Pre-processing

2.1.2.5.1 getsdr (getSDR.f)

This routine accesses SDR information needed by the algorithm for a particular FOR including IR radiances, MW BTs, and quality data. A flag is set if MW data is not available for the FOR.

2.1.2.5.2 calc_ir_noise (calc_ir_noise.f)

This routine calculates instrument and atmospheric noise values for each channel. IR instrument noise values are calculated through the interpolation of the tabulated NEdN noise at three different scene temperatures for each channel. Atmospheric noise can also be added.

2.1.2.5.3 calc_mw_noise (calc_mw_noise.f)

This routine calculates MW noise for an FOV. This routine is called for each FOV from calcCrimssProfiles.

2.1.2.5.4 bt (planck.f)

This routine converts spectral radiances to brightness temperatures. At a specified frequency, the function converts spectral radiances (mw/m^2/sr/cm^{-1}) to brightness temperatures (K).

2.1.2.5.5 xlint (calc_ir_noise.f)

This routine interpolates linearly between two points to get the function value.

2.1.2.5.6 draddt (planck.f)

This routine calculates the derivative of spectral radiance with respect to temperature for a specified frequency. This is a single-precision function. Please refer to ***dbdt*** for double-precision process.

2.1.2.5.7 setcovback (setCovBack.f)

This routine assigns background and its covariance according to land type (ocean or land). The land type for each FOR is currently determined from the average land fraction. This routine calls getNWP to get the surface pressure at each FOV which is adjusted for the difference between the NWP model height and the DEM terrain height. Adjusted surface pressure at the FOVs are averaged for the FOR surface pressure. The precipitation check is also performed for the FOR.

2.1.2.5.8 precip (setCovBack.f)

This routine uses the model from Ralph Ferraro, Branch Chief for the Satellite Climate Studies Branch, to detect precipitation.

2.1.2.5.9 setNWPCovBack (get_pres.f)

This routine assigns background and its covariance matrix according to land type (ocean or land). Land type is determined by average land fraction in the FOR. This routine calls getNWP which gets the surface pressure at each FOV adjusted for the difference between the NWP model height and the DEM terrain height, and constructs the first guess profile using NWP data. Adjusted surface pressure at the FOVs are averaged for the FOR surface pressure.

2.1.2.5.10 getNWP (get_pres.f)

This routine calls adjSfcPresAlt to get the adjusted surface pressure. This routine calls regridProf to construct the guess profile from NWP data if the flag is set.

2.1.2.5.11 adjSfcPresAlt (get_pres.f)

This routine adjusts NWP-derived surface pressure for local topography. It calculates the virtual temperature at levels for input into adjSfcPresPoint, which calculates the height-corrected surface pressure.

2.1.2.5.12 adjSfcPresPoint (get_pres.f)

This routine calculates the height-corrected surface pressure at the given lat/lon location.

2.1.2.5.13 Grav (get_pres.f)

This routine calculates the altitude adjusted acceleration due to gravity.

2.1.2.5.14 regridProf (get_pres.f)

This routine generates a guess profile at OSS levels using NWP temperature and moisture data.

2.1.2.5.15 dbdt (planck.f)

At a specified frequency, this function calculates the derivative of radiance (or brightness temperature) with respect to temperature (K). This is a double-precision function. Please refer to draddt for the single-precision process.

2.1.2.6 Microwave-only Retrieval

A description of the MW-only retrieval is given in the CrIS ATBD, Section 5.3. This module inverts MW spectral radiances to produce a first-guess profile for the joint MW and IR retrieval. The functions and subroutines utilized by this module are shown in Figure 7. The iteration process is performed until a preset maximum number of iterations is reached or the χ^2 convergence test is passed [see CrIS ATBD for the definition of χ^2]. The maximum number of iterations is passed into the algorithm (see CrIS ATBD, Section 5.2) and can be varied. An initial call to the subroutine ***map_retr2geo*** is performed to set up the initial guess profile vector (which is a copy of the background at this point) and to determine the surface skin temperature (determined in the routine ***lvl_int***). When the parameter ***covSelectMethod*** = 3 and the MW-only retrieval has converged, a stratified *a priori* field is assigned based on *Tskin* and land type. The MW-only retrieval is then repeated with the updated *a priori* field (which is also used during the following IR+MW retrieval). The CrIS ATBD, Section 5.3.1, describes the *a priori* stratification scheme in more detail.

Overview of microwave-only retrieval:

Perform MW forward model calculation to generate MW spectral radiances and derivatives corresponding to the first guess (background profile).

Enter inversion loop.

Set up measurement error covariance matrix using DRAD method described in the CrIS ATBD, Sections 4.3.2 and 7.1, map derivatives from geophysical space to retrieval space.

Perform inversion in retrieval space.

Map retrieved profile from retrieval to geophysical space.

Check to ensure retrieval parameters are within reasonable physical bounds.

Generate spectral radiance and derivatives based upon new profile.

Map profile from geophysical to retrieval space. Some parameters may be modified in the check procedure above, thus this mapping is needed.

Spectral radiance convergence is tested. Only a limited number of iterations is allowed.

Update the *a priori* field based on the retrievals using global ocean and land covariance matrices and repeat the MW-only retrieval.

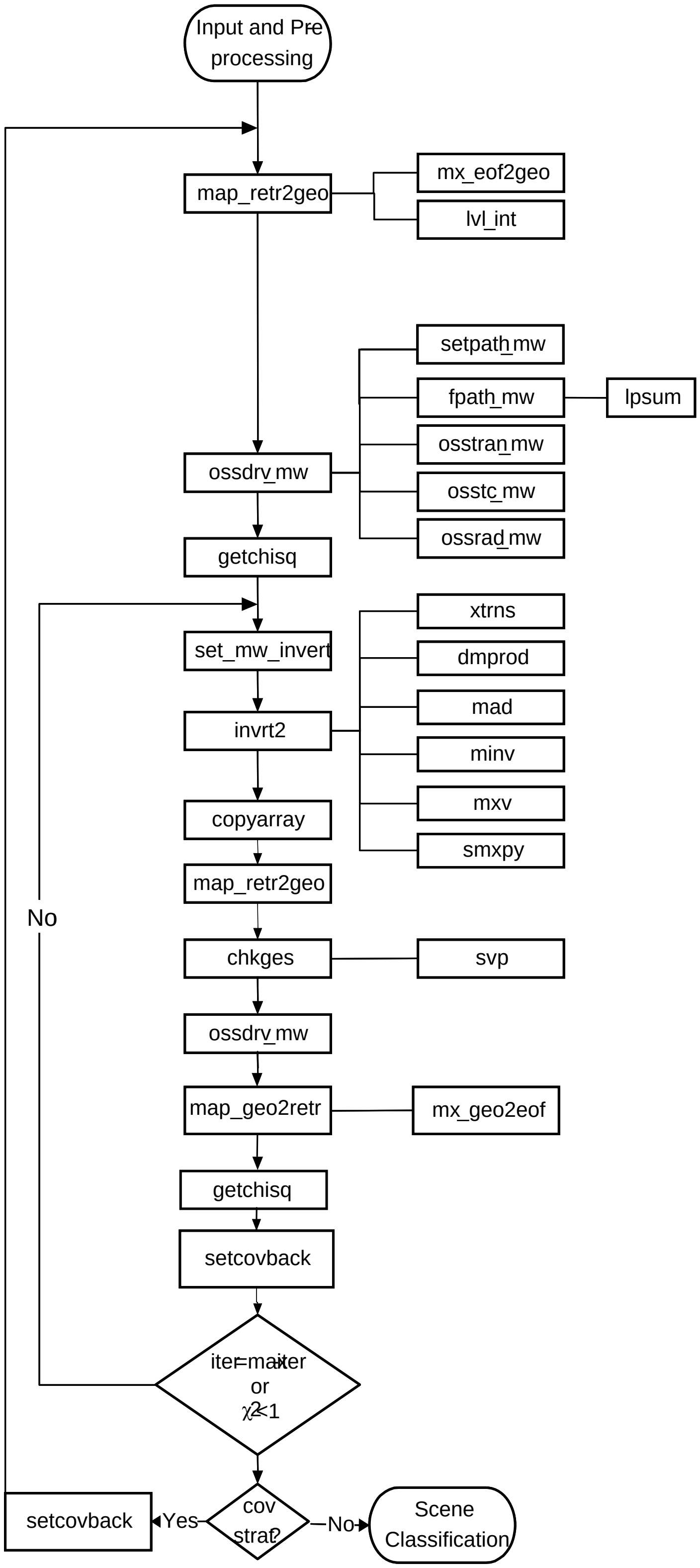

Figure 7. Software Components of Microwave-only Retrieval

2.1.2.6.1 map_retr2geo (map_retr2geo.f)

This routine converts parameters from the retrieval to the geophysical domain. Temperature and moisture are converted before being added to the background values. It is the opposite process to ***map_geo2retr***, discussed in Section 2.1.2.6.31.

2.1.2.6.2 mx_eof2geo (mx_eof2geo.f)

This routine is used by ***map_retr2geo*** to convert a matrix in the EOF (or retrieval) domain to the geophysical domain after the inversion process. The length in the EOF domain is generally shorter than that in the geophysical domain because of the application of eigenvectors.

2.1.2.6.3 lvl_int (lvl_int.f)

This routine computes the surface value via interpolation. The interpolation of variables at the surface is done in the logarithmic pressure coordinate, given the pressure and variable profiles, and the surface pressure.

2.1.2.6.4 ossdrv_mw (ossmw.f)

This routine is the driver for OSS MW forward model.

2.1.2.6.5 fpath_mw (ossmw.f)

This routine calculates MW layer-mean temperatures and layer amounts of H_2O. It computes the average temperature and molecular amounts for all layers for given profiles of temperature and moisture. It also calculates the derivatives of ***tavl*** with respect to a change in the lower and upper boundary temperatures and the derivatives of the H_2O layer amounts with respect to a change in the H_2O mixing ratio at the layer boundaries. Layer amounts are in molec./cm^2. This version is for plane parallel geometry. Integration assumes that T is linear in z (LnT linear in LnP) and LnQ linear in LnP. This subroutine expects water vapor mixing ratios in g/kg.

2.1.2.6.6 lpsum (ossmw.f)

This routine calculates average quantities (or integrated amount) using a log-x dependence on log-p.

2.1.2.6.7 gettropgrid (crims.f)

This routine sets trop limits indexing when given a pres grid.

2.1.2.6.8 Init_kfix (ossir.f)

This routine uses the standard mixing ratio for the fixed gases and absorption coefficient tables for the fixed gases to generate optical depths for fixed gas molecules.

2.1.2.6.9 Init_mwna (init_MwNA.f)

This routine initializes MW noise amplification based on MW noise amplification values read from DMS.

2.1.2.6.10 Interp2Freq (ossir.f)

This routine interpolates an input data array from an input grid to an output grid. An output data array is filled with the interpolated data.

2.1.2.6.11 getod_ir (ossir.f)

This routine performs initializations associated with the OSS absorption coefficient tables. It merges coefficients for nonvariable molecules with fixed gas coefficients.

2.1.2.6.12 ossin_mw (ossmw.f)

This routine loads parameters for the OSS model in the MW.

2.1.2.6.13 planckghz (ossmw.f)

This routine calculates Planck function with frequency in GHz as input.

2.1.2.6.14 osstran_mw (ossmw.f)

This routine calculates layer optical depths for molecular species in the MW.

2.1.2.6.15 osstc_mw (ossmw.f)

This routine calculates MW optical depths for liquid clouds. Based upon the features of the input cloud, i.e., the cloud top, cloud thickness and amount, the function calculates MW cloud optical depths at each monochromatic frequency for liquid clouds.

2.1.2.6.16 ossrad_mw (ossmw.f)

This routine calculates MW spectral radiances and derivatives. It computes brightness temperature (K) and their derivatives with respect to atmospheric and surface parameters. The function also computes transmittance before all the other processes. The upward transmittance is calculated based upon the downward one.

2.1.2.6.17 abcoefliq (ossmw.f)

This routine calculates MW cloud absorption coefficient. Computes absorption coefficient in m^2/kg for suspended water droplets.

2.1.2.6.18 cosmicbackg (ossmw.f)

This routine calculates the effective brightness temperature of the cosmic background.

2.1.2.6.19 setcctun (crims.f)

This routine sets CC tuning parameters. Given an apodization, the routine sets the cloud-clearing tuning parameters.

2.1.2.6.20 getchisq (crims.f)

This routine calculates Chi_Square for quality control. It returns the normalized Chi_square as well as rms.

2.1.2.6.21 set_mw_Invert (set_mw_invert.f)

This routine sets up the error covariance matrix in the MW band and converts derivatives from geophysical to retrieval domain prior to inversion.

2.1.2.6.22 invrt2 (invrt2.f)

This routine performs profile inversion by non-linear optimal estimation using a background profile and its error covariance as constraints (please refer to Section 4.3 of the CrIS ATBD for details). In order to accommodate the cray convention (row dimension = leading array dimension), the *k-matrix* (the Jacobian *k-matrix*) passed as an argument is stored as the transpose of the *k-matrix* in ***xkt***. The other matrices (***e***,***c***) are symmetrical. This version of ***invrt*** is to be used when the number of channels is smaller than the number of retrieved parameters (i.e., in the MW-only retrieval). All vector and matrix operations are in double precision.

2.1.2.6.23 xtrns (msub.f)

This routine transposes a matrix.

2.1.2.6.24 mad (msub.f)

This routine does addition of diagonal elements of a matrix and a vector.

2.1.2.6.25 dminv (dminv.f)

This routine does matrix inversion using the standard Gauss-Jordan method. The determinant is also calculated (double precision).

2.1.2.6.26 mxv (invrt1.f)

This routine computes the product of a matrix and a vector. The output is a vector with its length corresponding to the row length of the matrix.

2.1.2.6.27 smxpy (invrt1.f)

This routine does summation of a vector and product of a vector and a matrix. A vector of length ***n2*** is multiplied by an ***n2*** by ***n1*** matrix to generate a vector of length ***n1*** which is then added to another vector of length ***n1***.

2.1.2.6.28 copyarray (crims.f)

This routine copies an old array to a new array (used to copy the retrieval vector).

2.1.2.6.29 chkges (chkges.f)

This routine checks all variables within their physical limits. The temperature is checked against pre-defined lower and upper extremes. The moisture is checked against the saturation condition. For the MW cloud, two parameters are retrieved, i.e., cloud top and cloud amount. In this case, the covariance and values of these parameters are adjusted whenever they are out of physical allowances.

2.1.2.6.30 svp (chkges.f)

This routine calculates saturation vapor pressure in mb at a given temperature (K). Values correspond to saturation vapor pressure over water for temp > 5 deg.C, to saturation vapor pressure over ice for temp < 8 deg.C, and to transitional values in between.

2.1.2.6.31 map_geo2retr (map_geo2retr.f)

This routine converts parameters from the geophysical to the retrieval domain. Temperature and moisture are converted after being subtracted from the background values. It is the opposite process to ***map_retr2geo*** detailed in Section 2.1.2.6.1.

2.1.2.6.32 mx_geo2eof (mx_geo2eof.f)

This routine is used by ***map_geo2retr*** to convert a matrix in the geophysical domain to the EOF (or retrieval) domain before the inversion process. The length in the EOF domain is generally shorter than that in the geophysical domain because of the application of eigenvectors which makes the inversion much faster.

2.1.2.6.33 setcovback (setCovback.f)

See Section 2.1.2.5.7.

2.1.2.6.34 ossinit_mw (ossmw.f)

This routine initializes OSS MW parameters.

2.1.2.6.35 setpath_mw (ossmw.f)

This routine sets up the view path, up looking or down looking.

2.1.2.6.36 settabindx_mw (ossmw.f)

This routine computes coefficients for temperature and moisture interpolation of MW OSS data.

2.1.2.6.37 copy1stguess (calcCrimmsProfile.f)

This routine makes a copy of the geophysical parameters.

2.1.2.7 Scene Classification

A detailed description of the scene classification module is given in the CrIS ATBD, Section 5.4. Functions and subroutines utilized by this module are shown in Figure 8. The purpose of this module is to maximize the number of successful retrievals under cloudy conditions. The module clusters FOVs within an FOR based on the number of estimated cloud formations, and decides on the cloud-treatment strategy based on the spectral radiance contrast within each cluster. The current scheme is designed to work with the cloud-clearing approach. The algorithm for estimating the number of cloud formations has been preliminarily validated using IPO-supplied scanline data sets, but the clustering schemes and post-processing under different scenarios have not been fully tested.

Overview of scene classification:

The initial guess profile is set up with both MW and IR specific parameters.

The MW and IR clear-sky spectral radiances and derivatives are calculated, that are needed for:

Setting the clear flag *iclrflg*.

Second stage retrieval.

Determining the clear flag *iclrflg*.

Estimate the number of cloud formations *NCF* according to the method described in the CrIS ATBD, Section 5.4.3. Principal components are calculated using Singular Value Decomposition (SVD).

Group FOVs into clusters. Two clustering schemes are implemented in the operational code. For operational purposes, the *sceneClassMode* = 1 option is recommended, which generates clusters of 1, 4, or 9 FOVs (depending on the estimated number of cloud formations). See the CrIS ATBD, Section 5.4.4 for details.

For each cluster, if *NCF* = 0, set *ccflag* = *.false.* and *clrflg* = *.false* if *iclrflg* = *.false.* and *ccflag* = *.true.,* and set *clrflg* = *.true.* if *iclrflg* = *.false.* The same flags are set if *NCF* $\neq$ 0 and the cluster does not exhibit sufficient thermal contrast. If *NCF* $\neq$ 0 and the cluster does exhibit thermal contrast, then the cluster is checked to see whether it contains enough FOVs of the same surface type (land or ocean) to be consistent with *NCF*. If the number of FOVs of the same predominant surface type is sufficient, then *ccflag* = *.true.* and *clrflg* = *.false.*, otherwise *ccflag* = *.false.* and *clrflg* = *.true.*. In *sceneClassMode* = 3 the retrieval algorithm is directed to perform cloud clearing (*ccflag* = *.true.* and *clrflg* = *.false.*).

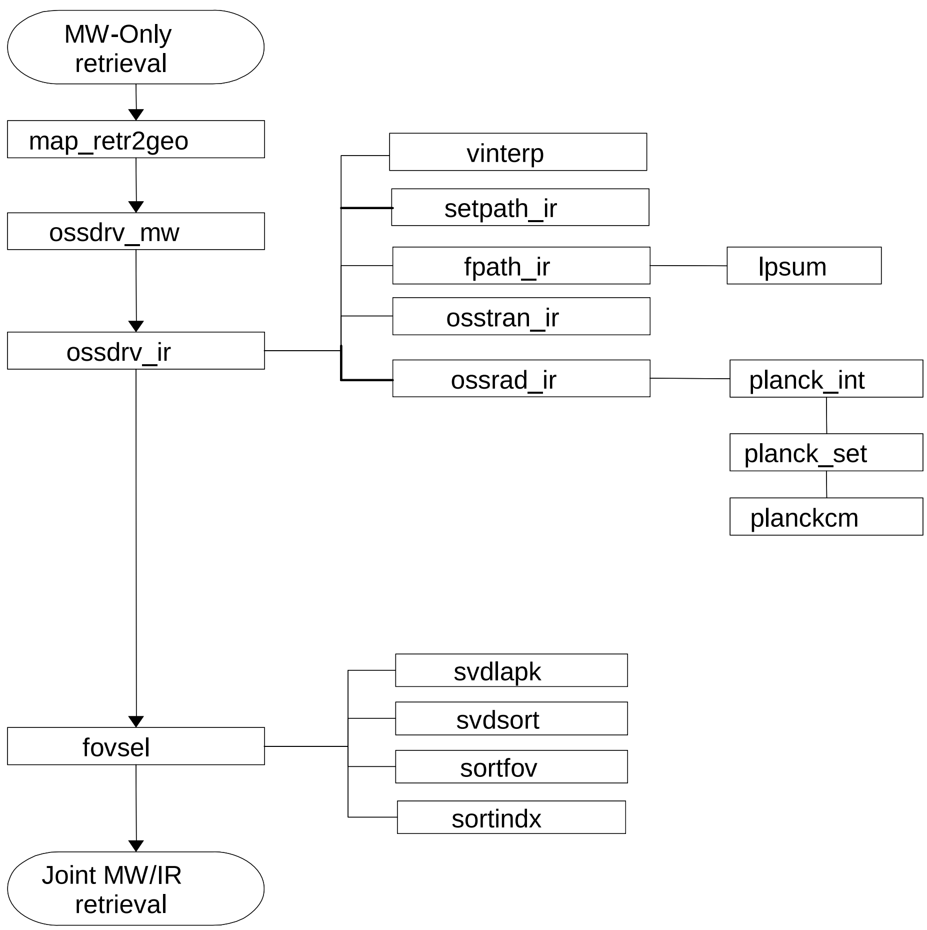

Figure 8. Software Components of Scene Classification

2.1.2.7.1 map_ret2geo (map_retr2geo.f)

See Section 2.1.2.6.1.

2.1.2.7.2 ossdrv_mw (ossmw.f)

See Section 2.1.2.6.4.

2.1.2.7.3 ossdrv_ir (ossir.f)

This routine is a driver for the OSS IR forward model.

2.1.2.7.4 fpath_ir (ossir.f)

This routine calculates layer-mean temperatures and molecular column amounts. It computes the average temperature and molecular amounts for all layers for given profiles of temperature and molecular concentrations. It also calculates the derivatives of layer average temperatures with respect to a change in the lower and upper boundary temperatures and the derivatives of the molecular amounts with respect to a change in the mixing ratios at the layer boundaries. Molecular amounts are in gm/cm^2. This version is for plane parallel geometry. Integration assumes that T is linear in z (LnT linear in LnP) and LnQ linear in LnP. This subroutine is expecting mixing ratio for the molecular species in ppmv.

2.1.2.7.5 lpsum (ossmw.f)

See Section 2.1.2.6.6.

2.1.2.7.6 osstran_ir (ossir.f)

This routine computes IR transmittance.

2.1.2.7.7 ossrad_ir (ossir.f)

This routine calculates IR spectral radiances and derivatives of radiances with respect to atmospheric and surface parameters.

2.1.2.7.8 planck (planck.f)

This routine calculates Planck function and its derivative with respect to temperature. At specified frequencies, it calculates the derivatives of radiance (or brightness temperature) with respect to temperature (K). This is a single-precision function. Please refer to ***dbdt*** for double-precision process.

2.1.2.7.9 avgrad (crims.f)

This routine calculates the average radiance for the CrIS channels. It is used to calculate the average radiance when there is no thermal contrast between adjacent FOVs.

2.1.2.7.10 draddt (planck.f)

See Section 2.1.2.5.6.

2.1.2.7.11 fovsel (fovsel.f)

This routine groups FOVs into clusters. The number of cloud formations within an FOR is estimated and FOVs within the FOR are grouped into clusters.

2.1.2.7.12 svdlapk (svdlapk.f)

This routine does single value decomposition of a given matrix. Given an ***m*** x ***n*** matrix ***a***, with physical dimensions ***mp*** x ***np***, this routine computes its singular value decomposition, $A=U\bullet w\bullet V^T$. The matrix U replaces ***a*** on output. The diagonal matrix of singular values ***w*** is output as a 1 x ***n*** vector. The matrix ***V*** (not V^T) is ***n*** x ***n*** square matrix (single precision).

2.1.2.7.13 sortfov (fovsel.f)

This routine sorts FOVs. It is used by **fovsel** to arrange FOVs in descending order according to their cloud-cleared spectral radiances. The sorted indices are returned.

2.1.2.7.14 sortindx (fovsel.f)

This routine assigns sorting indices. This subroutine is called by **fovsel** to insert an index to an existing index array in ascending order.

2.1.2.7.15 vinterp (ossir.f)

This routine interpolates from the input frequency grid to the OSS spectral grid.

2.1.2.7.16 ossinit_ir (ossir.f)

This routine calls getod_ir which gets absorption coefficients, sets up solar array for OSS spectral channels, assigns input parameters to local counterparts, and gets reference trace gas profiles.

2.1.2.7.17 dsvdlapk (svdlapk.f)

This routine computes SVD (double precision version of svdlapk).

2.1.2.7.18 getrefprof (GetRefProf.f)

This routine assigns the reference profile.

2.1.2.7.19 setpath_ir (ossir.f)

This routine sets up the view path, up looking or down looking.

2.1.2.7.20 settabindx (ossir.f)

This routine computes coefficients for temperature and moisture interpolation of IR OSS data.

2.1.2.7.21 shrink (ossir.f)

For those molecules which are loaded as variable molecules but are not going to be retrieved, this routine merges them with the fixed gas molecules.

2.1.2.7.22 planck_int (ossir.f)

This routine computes Planck function and its derivative with respect to temperature.

2.1.2.7.23 planck_set (ossir.f)

This routine calculates the Planck radiance at a single wave number and its derivative with respect to temperature for a number of layers.

2.1.2.7.24 planckcm (ossir.f)

This routine calculates the Planck function and its derivative with respect to temperature.

2.1.2.8 Microwave and Infrared Joint Retrieval

This module, which forms the core of the CrIMSS retrieval algorithm, is described in detail in the CrIS ATBD, Section 5.5. Its software components are shown in Figure 9. The retrieval proceeds among four possible paths, depending on the set of flags, *ccflg* and *clrflg* (each with a value of .*true*. or .*false*.), during scene classification (see Section 2.1.2.7). As is the case at the first stage retrieval, the iteration continues until the maximum number of iterations is reached or until χ^2 has converged to below a predetermined value. Although not shown in the flow chart, there is also a check on the variation of χ^2 with iterations. The complete convergence criteria adopted in the current code are for χ^2 to be less than 0.7 and χ^2 variation to be less than 10% from iteration to iteration.

Overview of microwave and infrared joint retrieval:

For each FOV cluster, if *ccflg* = *.false.*, skip the cluster and go to the next cluster; otherwise,

Generate cloud-cleared spectral radiances (if *ccflg* = *.true.* and *clrflg* = *.false.*), or assume a clear FOV (if *ccflg* = *.true.* and *clrflg* = *.true.*).

Enter inversion loop.

Set up measurement error covariance matrix using the DRAD method, map derivatives from geophysical to retrieval space. At first iteration, the derivatives obtained by calling the forward model during scene classification are used. Subsequently, derivatives calculated at the previous iteration are used.

Perform inversion in retrieval space.

Map retrieved profile from retrieval to geophysical space.

Check to ensure retrieval parameters are within reasonable physical bounds.

Generate spectral radiances and derivatives based upon new profile.

Map profile from geophysical to retrieval space. Some parameters may be modified in the check procedure above, thus this mapping is needed.

Spectral radiance convergence is tested. Only a limited number of iterations is allowed.

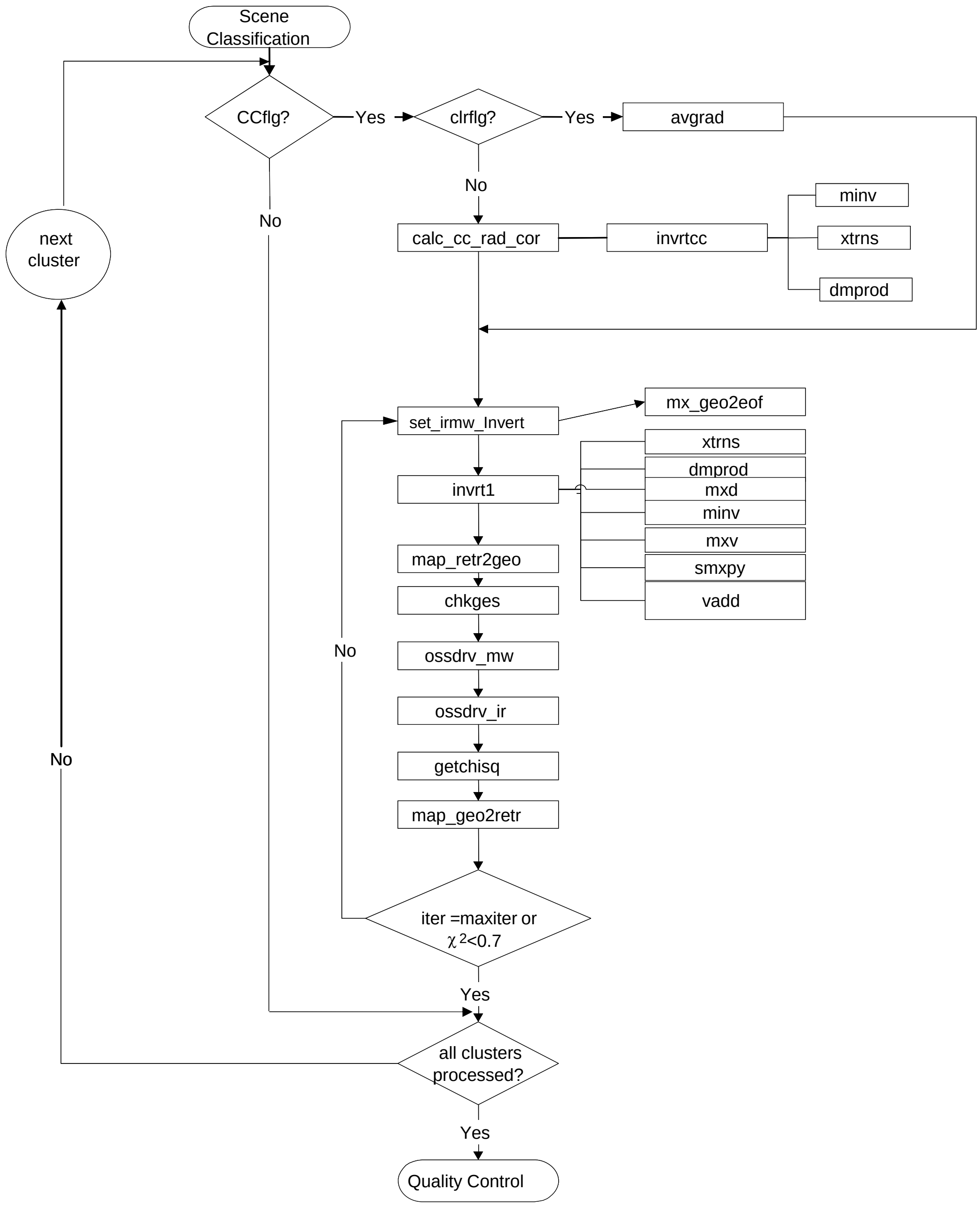

Figure 9. Software Components of Joint Microwave+Infrared

2.1.2.8.1 calc_cc_rad_cor (calc_cc_rad.f)

This routine calculates cloud cleared spectral radiances. It uses channel observations in adjacent potentially partially cloudy scenes to reconstruct what the channel radiances would have been if the scenes were clear. The assumption is that the FOVs are homogeneous except for the amount of cloud cover in *K* different cloud formations in each FOV. The cloud clearing is applied to FOV clusters formed during scene classification. For more information about the algorithm, please refer to the CrIS ATBD, Section 5.5.2.

2.1.2.8.2 findtrop (crims.f)

This routine determines the pressure level of the tropopause given a temperature profile. (invrtcc.f)

2.1.2.8.3 invrtcc (invrtcc.f)

This routine calculates the cloud-clearing parameter "eta" and is defined as the "unknown channel independent constant" (Susskind and Joiner, 1993,) TBS01. By using the linear combination, this function calculates the value of "eta" for later generating cloud-cleared spectral radiance (see calc_cc_rad). SVD is employed to stabilize the solution for nearly-clear scenes. All vector and matrix operations are in double precision.

2.1.2.8.4 xtrns (msub.f)

See Section 2.1.2.6.23.

2.1.2.8.5 dmprod (dmprod.f)

This routine is the standard function for multiplying two matrices.

2.1.2.8.6 set_irmw_invert (set_irmw_invert.f)

This routine converts parameters from geophysical to retrieval domain in the IR band. This subroutine sets up the error covariance matrix for the MW+IR retrieval and converts derivatives from the geophysical to the retrieval domain prior to inversion. Error terms from O3 are included.

2.1.2.8.7 mx_geo2eof (mx_geo2eof.f)

See Section 2.1.2.6.32.

2.1.2.8.8 invrt1 (invrt1.f)

The inversion is performed by non-linear optimal estimation using a background profile and its error covariance as constraints (refer to the CrIS ATBD, Section 4.3 for details). In order to accommodate the cray convention (row dimension = leading array dimension), the *k-matrix,* passed as an argument, is stored as the transpose of the *k-matrix* in ***xkt***. The other matrices (***e***,***c***) are symmetrical. This version of ***invrt*** is to be used when the number of channels is larger than the number of retrieved parameters (i.e., in the MW+IR retrieval). All vector and matrix operations are in double precision.

2.1.2.8.9 gen_var (invrt1.f)

This routine calculates UR output covariance and standard deviation. Input is the UR covariance in retrieval space and is transformed to geophysical space. Outputs are both the full covariance and the standard deviation. (This is not in use by the operational code at this time.)

2.1.2.8.10 xtrns (msub.f)

See Section 2.1.2.6.23.

2.1.2.8.11 mxd (msub.f)

This routine calculates the product of a matrix and a vector. (double precision)

2.1.2.8.12 vadd (msub.f)

This routine calculates the sum of two vectors. (double precision)

2.1.2.8.13 mxv (invrt1.f)

See Section 2.1.2.6.26.

2.1.2.8.14 smxpy (invrt1.f)

See Section 2.1.2.6.27.

2.1.2.8.15 map_retr2geo (map_retr2geo.f)

See Section 2.1.2.6.1.

2.1.2.8.16 chkges (chkges.f)

See Section 2.1.2.6.29.

2.1.2.8.17 ossdrv_mw (ossmw.f)

See Section 2.1.2.7.2.

2.1.2.8.18 ossdrv_ir (ossir.f)

See Section 2.1.2.7.3.

2.1.2.8.19 getChiSq(crims.f)

See Section 2.1.2.6.20.

2.1.2.8.20 map_geo2retr (map_geo2retr.f)

See Section 2.1.2.6.31.

2.1.2.8.21 cldretr (cldRetr.f)

This subroutine uses the atmospheric parameters retrieved from MW and cloud-cleared radiance to retrieve cloud parameters.

2.1.2.9 Quality Control(QC)

This module is described in the CrIS ATBD, Section 5.6, and its structure is presented in Figure 10. At present, the QC module assesses the quality of the retrieved profiles using four criteria. Some of the parameters on which the criteria are based are calculated outside the module and are used as inputs, while others are calculated inside the module. The result of each test for each retrieval is reflected in bit flags within the retrieval quality flags. The criteria which we are calling χ^2 AIRS is not discussed in the CrIS ATBD since it is in the evaluation stage. More work on the QC module is needed in order to effectively identify poor retrievals due to scenes with low cloud contrasts.

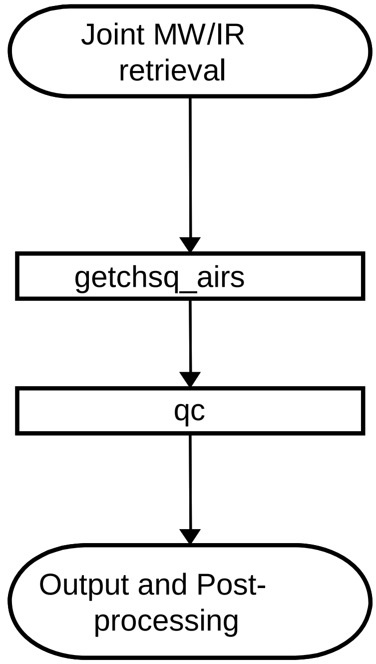

Figure 10. Software Components of Quality Control

2.1.2.9.1 getchisq_airs (crims.f)

This routine calculates chi square value in the CC region using the AIRS approach.

2.1.2.9.2 qc (qc.f)

This routine sets quality control flags, one for each test. A separate flag is passed from the routine which indicates whether all tests passed or not.

2.1.2.9.3 putRetrInfo (putRetrInfo.f)

Temperature and moisture profiles at the OSS levels are stored to an intermediate structure. This structure is accessed by functions in the CrIMSS derived algorithm class which convert the level data to the EDR output layers. Additional retrieval information is also stored to the structure to be included in the EDR/IP output structures. If the routine is called with the fill flag set to true, the retrieval profiles are set to the CRIMSS_FLOAT32_FILL value.

2.1.2.10 Output and Post-processing

When the CrIMSS processing has finished, the gridEdr method of the ProEdrCrimssAtmProf class converts the output retrieval data at the OSS levels to the EDR reporting layers to obtain the final EDR products. The EDR output items are written to DMS as a final step.

2.1.2.10.1 generateEdrs (proEdrCrimssAtmProf.cpp)

Figure 11 shows the flow diagram for generateEdrs. This method does the initialization for interpolation of the intermediate retrieval results to get the final EDR output at the reporting grids. This method calls convertPressure() to convert the pressure values to the EDR output grid and convertTempMoisture() to convert the temperature and moisture values to the EDR output grid. This method takes level data calculated by calcCrimssProfiles and converts it to layer data. The size of the output EDRs is determined by the number of retrievals returned in the crimssAlgData_crimssRetrLvlDataPtr structure.

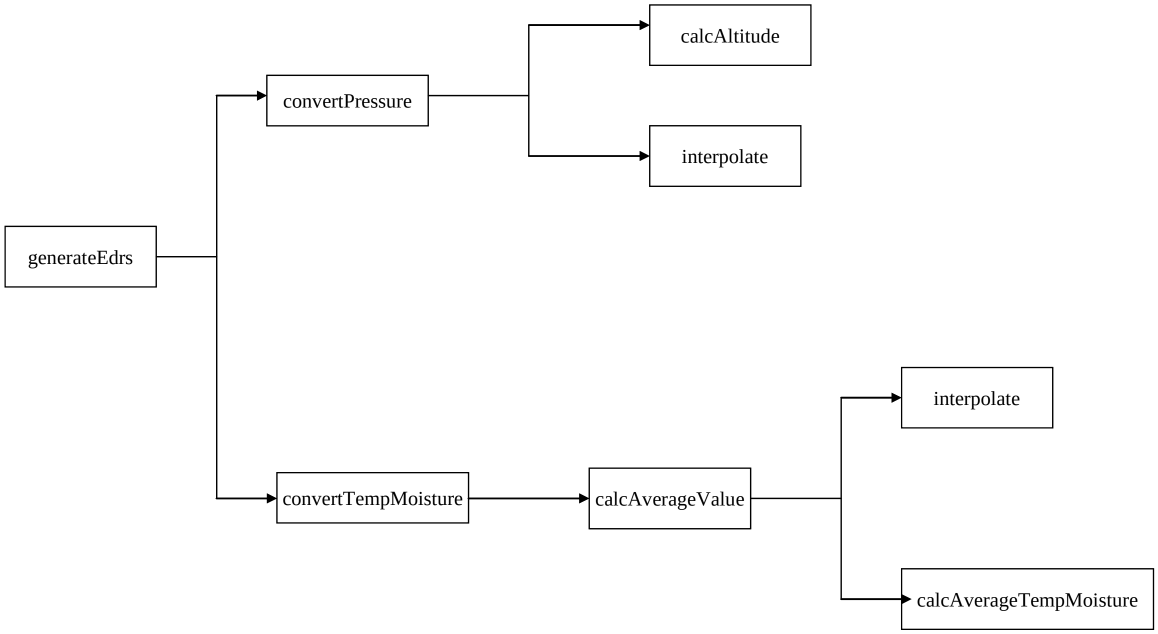

Figure 11. GenerateEdrs Flow Diagram

2.1.2.10.2 convertPressure (proEdrCrimssAtmProf.cpp)

This method converts the pressure values to the reporting grid space.

2.1.2.10.3 convertTempMoisture (proEdrCrimssAtmProf.cpp)

This method converts the temperature and moisture values to the reporting grid space.

2.1.2.10.4 calcAltitude (proEdrCrimssAtmProf.cpp)

This method converts pressure levels to altitude levels using temperature and moisture profiles.

2.1.2.10.5 interpolate (proEdrCrimssAtmProf.cpp)

This method interpolates between reference and standard grids.

2.1.2.10.6 calcAverageValue (proEdrCrimssAtmProf.cpp)

This method computes the average value of reference temperature or moisture vectors.

2.1.2.10.7 calcAverageTempMoisture (proEdrCrimssAtmProf.cpp)

This method computes layer averages of interpolated temperature and moisture data.

2.1.2.10.8 FillOutputEdrs (proEdrCrimssAtmProf.cpp)

This method is called after generateEdrs and fills the DMS output EDR buffers with converted layer data.

2.1.2.10.9 fillOutputIps (proEdrCrimssAtmProf.cpp)

This method is called after generateEdrs and fills the DMS output IP buffers with data that was stored to an intermediate structure during algorithm processing.

2.1.2.10.10 setupDataQuality (proEdrCrimssAtmProf.cpp)

This method creates DQN quality objects used by the common IO code to run the tests to determine whether a DQN should be generated for an EDR or the Ozone IP. Also, a fill quality threshold object is created which is used to generate metadata indicating how many retrievals in the granule contain fill.

2.1.3 Graceful Degradation

If MW SDR data is not available, NWP data is used to generate the first guess profile. If CrIS SDR data is not available, the algorithm generates MW only retrievals and set quality flags accordingly. Table 8 summarizes the action taken if an input to the algorithm is missing. If the algorithm fails, no output products are produced for the granule being processed.

Table 8. Graceful Degradation Summary

Primary Inputs	Secondary Inputs	Required ® or Optional (O)	Action
CrIS SDR (unapodized)	None	R	Process using MW data only
ATMS SDR (resampled to center CrIS FOV)	NWP model data	R	Use NWP data if MW data is not available
CrIMSS Channel Selection LUT	None	R	Fail if missing
CrIMSS IR Noise	None	R	Fail if missing
CrIMSS MW Noise	None	R	Fail if missing
CrIMSS Climate Data	None	R	Fail if missing
CrIMSS Surface Emissivity	None	R	Fail if missing
CrIMSS Solar Data	None	R	Fail if missing
CrIMSS Day LAA Coefficients	None	R	Fail if missing
CrIMSS Night LAA Coefficients	None	R	Fail if missing
CrIMSS MW Frequency andPolarization	None	R	Fail if missing
CrIMSS Day LAA EOF	None	R	Fail if missing
CrIMSS Night LAA EOF	None	R	Fail if missing
CrIMSS MW OSS Coefficients	None	R	Fail if missing
CrIMSS IR OSS Coefficients	None	R	Fail if missing
CrIMSS MW Absorption Coefficients	None	R	Fail if missing
CrIMSS IR Absorption	None	R	Fail if missing

Primary Inputs	Secondary Inputs	Required ® or Optional (O)	Action
Coefficients			
CrIMSS MW Noise Amplification Factor	None	R	Fail if missing
CrIMSS Configurable Parameters	None	R	Fail if missing
CrIMSS IR Channel Atmospheric Noise	None	R	Fail if missing
CrIMSS MW Channel Atmospheric Noise	None	R	Fail if missing
CrIMSS Trace Gas Reference Profiles	None	R	Fail if missing
CrIMSS Above Tropopause Reference Profiles	None	R	Fail if missing
NWP to CrIMSS Conversion Coefficients for Temperature	None	R	Fail if missing
NWP to CrIMSS Conversion Coefficients for Moisture	None	R	Fail if missing
Terrain Height	None	R	Fail if missing
NWP Temp and Moisture	None	O	No adjustments to surface pressure if missing
NWP Surface Pressure	None	O	Use elevation and standard profile assumption to estimate surface pressure if missing
CrIMSS EDR Quality Threshold Table	None	O	If missing no quality tests are executed
CrIMSS IR Ozone IP Quality Threshold Table	None	O	If missing no quality tests are executed

2.1.4 Exception Handling

The CrIMSS EDR retrieval algorithm produces AVTP, AVMP, and PP EDRs under most circumstances. In cases where there are checks in the code where processing can be discontinued, the subroutine returns either PRO_SUCCESS or PRO_FAIL back to the caller. There are only a few cases where algorithm processing must be discontinued:

If dimensions of some of the LUT data exceed dimensions used in the algorithm, the algorithm processing does not continue. The LUT data is static and this should not occur unless there is a serious problem with DMS or if the LUTs are updated by mistake.

There are a few instances where values which are adjustable could result in a divide by zero.

When algorithm processing is discontinued, a status message is sent to Infrastructure describing the error in the following manner:

A PRO_ERROR status is returned from the subroutine.

This status is propagated through calling routines down to the main Fortran algorithm routine (calcCrimssProfiles).

The calcCrimssProfiles routine ends and returns the status to the C++ wrapper routine which called the Fortran algorithm (ProEdrCrimmsAtmProfiles:doProcessing).

When doProcessing receives a PRO_ERROR status, it sends a message to Infrastructure indicating the algorithm ended with an error and no output products are produced for the granule.

In the case where adjustable values would result in a fatal error, but processing can continue using a reasonable value, a warning status message is sent to Infrastructure and the input value adjusted. For instance, if the maximum number of MW or IR iterations is adjusted beyond the maximum dimensions in the code, a warning message is sent to Infrastructure and the values are set to the maximum dimension in the algorithm code.

2.1.4.1 First Guess Error Checks

Subroutine **chkges** performs several checks to make sure the first guess profile is reasonable. The first guess profile is checked on each iteration. The skin temperature and retrieved temperatures at the OSS levels are checked against the range defined by the maxTemp and minTemp adjustable parameters. If any temperatures fall outside of the range, the data for this retrieval is set to fill. Also, a debug message indicating the error is logged if debug is turned on. The moisture profile is checked to determine whether any level is supersaturated. If a level is determined to be supersaturated, it is set to the saturation mixing ratio. A debug message is also logged if debug is turned on. **chkges** also checks for any 0.0 moisture values and resets them to a very small value (1.0E-12 g/kg) to avoid the possibility of a divide by zero during processing.

2.1.4.2 Missing NWP Data

NWP data is considered missing if the NWP data for a particular granule cannot be found in DMS, or the data values in a granule are set to missing. If NWP data is not available, the surface pressure is calculated using the elevation at the FOV and assuming a profile with a skin temperature of 280 K and a lapse rate of 6 K/km. If MW data is not available, and NCEP data is also not available, a first stage retrieval profile cannot be generated and the getNWP issues a PRO_FAIL status as well as logs an error message.

In the event that not all NWP data needed to perform the surface pressure adjustment is available, but NWP surface pressure is available, the NWP surface pressure is used without adjusting for the DEM versus model surface height. A message to this effect is issued to the log file.

2.1.5 Data Quality Monitoring

After the first stage retrieval iterations are completed, the first stage retrieval χ^2 value is checked against a configurable value (chiSqMwMax) to determine if it has converged sufficiently. If it does not exceed the threshold, the convergence flag for the MW only retrieval is set to true. After the second stage retrieval iterations are completed, the qc subroutine is called and applies several tests (described in Section 2.1.5.1). If the first and last tests are passed, the retrieval is of sufficient quality and the convergence flag for the combined IR+MW retrieval is set to true. If the first stage (MW only) retrieval converges, but the second stage (MW+IR) retrieval fails to converge, the first stage retrieval is used. The only exception is if the first stage retrieval was constructed using NWP data. In this case if the IR+MW retrieval convergence flag is false, the first stage retrieval is not used and the retrieval data is set to a fill value.

If both the first stage and second stage retrievals fail to converge, the retrieval data is set to ERR_FLOAT32_FILL values. Within the retrieval quality flags, there are flags which indicate whether the MW and MW+IR retrievals converged. There is also a flag which indicates whether the retrieval used for the EDR is the MW only or MW+IR retrieval. There is also a flag which indicates whether MW data was available for the retrieval. The flags are shown below in the retrieval quality flag summary table, Table 10.

2.1.5.1 QC Subroutine

The qc subroutine currently performs four tests and sets QC flags according to the results. During processing, noise weighted spectral radiance residual χ^2 are tracked. If the residual is greater than a pre-determined threshold then the QC flags are set accordingly. Also, the rms of retrieved profiles of the second and first stages is checked and a QC flag is updated. These are the retrieval quality checks performed by the qc subroutine:

There are four qc flags that are initialized as 0.

If the second stage MW+IR radiance matching χ^2 value is greater than a configurable value (chiSqMax), set the first QC flag to 1.

If the rms difference between the MW only and MW+IR profiles is greater than a configurable value (profDiffMax) and percentage of land is 0.0, set the second QC flag to 1. The test is not done if MW data is not available.

If the AIRS χ^2 value is greater than a configurable maximum value (chiSqAirsMax), set the third QC flag to 1.

If the second stage MW radiance matching χ^2 value is greater than a configurable value (chiSqMw2Max), set the fourth QC flag to 1. The test is not done if MW data is not available.

If the first and fourth QC flags are both 0, then the Convergence flag for combined IR+MW retrieval (in Table 10) is set to 1 (converged).

2.1.5.2 SDR Quality

The CrIS and ATMS SDR processing algorithms do quality checking of their output data. The CrIS SDR algorithm provides a quality flag for each FOV in each of the three CrIS bands. The resampled ATMS data is set to missing if there were not enough samples to perform the resampling for a given channel. If an ATMS channel to be used in the retrieval is set to missing, the channel selection flag for this channel is turned off for that retrieval via the channel selection flags. If all ATMS channels are missing for a particular FOR, the mwOff flag is set to true for that FOR. If any of the ATMS channels used in the precipitation detection routine are turned off, the precipitation detection routine is not executed and a debug message is issued to log that the routine was not run.

If a detector for a CrIS band is determined to be bad, the corresponding element in the detectorQF array is set to bad and that detector is not used in retrievals within the corresponding FOR in which the flag was set. The “CrIS SDR quality” bit flag from the CrIS SDR is read to determine whether the quality of a detector is bad. The CrIS SDR quality flags are documented in the CrIS SDR OAD.

There are bit flags in the retrieval quality bytes (Table 10) which indicate whether an ATMS channel was not used in a retrieval due to quality.

2.1.5.3 Quality Data Summary

Quality information is included with the CrIMSS EDR and CrIMSS IR Ozone IP outputs. The quality data is produced for each retrieval so it is dimensioned by the number of retrievals in the granule. The quality data includes the fields in Table 9.

Table 9. Quality Data Fields

Field	Type	Dimension	Description	Units
Land fraction	Float32	Number of retrievals in the granule	Average using all of the FOVs in the FOR for which the retrieval was generated.	Percent
Iterations needed for convergence	Int32	Number of retrievals in the granule	Number of iterations needed for the second stage retrieval to converge. If the second stage retrieval was not produced, it consists of the number of iterations needed for the MW only retrieval to converge.	None
Second stage residual	Float32	Number of retrievals in the granule	Second stage (IR+MW) radiance matching residual (weighted by sensor errors).	None
First stage MW residual	Float32	Number of retrievals in the granule	First stage (MW only) MW radiance matching residual weighted by SDR uncertainty.	None
Second stage MW residual	Float32	Number of retrievals in the granule	Second stage (IR+MW) MW radiance matching residual weighted by SDR uncertainty.	None
IR noise amplification factor	Float32	Number of retrievals in the granule	The final IR noise amplification/reduction factor estimate calculated for the retrieval.	None
Profile RMS difference	Float32	Number of retrievals in the granule	RMS difference between the lowest six levels of the first stage (MW only) and second stage (MW+IR) temperature profiles.	None
Ozone Spectral Signature (In CrIMSS IR Ozone IP output product only)	Float32	Number of retrievals in the granule	Difference between ozone absorption radiance and the background radiance.	mW/(m^2 sr cm^-1)
Granule quality bit flags	Byte	4	Quality bit flags for the granule.	None
Retrieval quality bit flags	Byte	(Number of retrievals in the granule) * 7	Quality bit flags for each retrieval.	None

The retrieval quality bit flags for a retrieval are contained in eight bytes. These flags are included in the CriMSS EDR and CrIMSS IR Ozone IP outputs and are shown in Table 10. There are also four bytes of granule level quality flags in these outputs. These are shown in Table 11.

There is also metadata attached to the EDR output product in DMS which indicates quality tests which were performed as well as the number of retrievals which were set to fill in the granule.

Table 10. Retrieval Quality Bit Flags

Retrieval Flag	# bits	Position in Quality Word	Description
Convergence flag for combined IR+MW retrieval	1	0	Applies to all layers in retrieval 0 = did not converge 1 = converged
Convergence flag for MW only retrieval	1	1	Applies to all layers in retrieval 0 = did not converge 1 = converged
Overall Retrieval Quality	2	2-3	Overall quality of retrieval 2 = High (IR + MW) 1 = Low (IR or MW only) 0 = Poor (non-converged)
IR-MW Profile QC Flag	1	4	0=IR – MW profile diff. did not exceed threshold 1=IR – MW profile diff. exceeded threshold
Spare	3	5-7	
Quality Byte #2			
Clear/Cloudy Flag	1	0	Indicates scene conditions for clouds within the FOR as clear or cloudy (Appendix D of the NPOESS System Specification, SY15-0007) 0 = clear 1 = cloudy
Rain flag	1	1	0 = no detectable precipitation 1 = precipitation detected in scene
Retrieval cell size	2	2-3	Number of FOVs used for the retrieval 0 = 9 FOVs used 1 = 4 FOVs used 2 = 1 FOV used
Retrieval type	1	4	0 = MW only 1 = (MW + IR) or IR only
Temperature Out-of_Range flag	1	5	This flag indicates that the atmospheric temperature at one or more of the pressure levels, or the surface skin temperature, is out of the expected range 0 = all level in range 1 = one or more levels out of range
Coast Flag	2	6-7	0 = ocean 1 = land 2 = coast
Quality Byte #3			

Retrieval Flag	# bits	Position in Quality Word	Description
Sun glint flag	1	0	Indicates Sun Glint within the FOR 0 = no sun glint 1 = sun glint
ATMS SDR Quality	7	1-7	Channels 1 through 7 One bit flag per channel 0 = ok 1 = channel not used due to quality
Quality Byte #4			
ATMS SDR Quality	8	0-7	Channels 8 through 15 One bit flag per channel 0 = ok 1 = channel not used due to quality
Quality Byte #5			
ATMS SDR Quality	7	0-6	Channels 16 through 22 One bit flag per channel 0 = ok 1 = channel not used due to quality
ATMS Availability	1	7	0 = ATMS data not available 1 = ATMS data available
Quality Byte #6			
Spares	8	0-7	
Quality Byte #7			
Non-LTE Flag	1	0	Indicates a non-LTE (non-Local Thermodynamic {temperature and pressure} Equilibrium) condition 0 = LTE 1 = Non-LTE
Day/Night Flag	1	1	Indicates whether in daytime or nighttime conditions 0 = day 1 = night
Spares	6	2-7	
Quality Byte #8			
CrIS Input SDR Quality	8	0-7	Percent of CrIS channels not used due to poor quality

Table 11. Granule Quality Bit Flags

Granule Flag	# bits	Position in Quality Word	Description
CrIS SDR Detector Failure	8	0-7	Detectors 1 through 8 (LWIR band) One bit flag per detector 0 = no detector failure 1 = detector failure
Quality Byte #2			
CrIS SDR Detector Failure	1	0	Detector 9 (LWIR band) 0 = no detector failure 1 = detector failure
CrIS SDR Detector Failure	7	1-7	Detectors 1 through 7 (MWIR band) One bit flag per detector 0 = no detector failure 1 = detector failure
Quality Byte #3			
CrIS SDR Detector Failure	2	0-1	Detectors 8 and 9 (MWIR band) One bit flag per detector 0 = no detector failure 1 = detector failure
CrIS SDR Detector Failure	6	2-7	Detectors 1 through 6 (SWIR band) One bit flag per detector 0 = no detector failure 1 = detector failure
Quality Byte #4			
CrIS SDR Detector Failure	3	0-2	Detectors 7 through 9 (SWIR band) One bit flag per detector 0 = no detector failure 1 = detector failure
Apodization Flag	2	3-4	Indicates which apodization was used 0 = No Apodization 1 = Blackman-Harris 2 = Hamming
Spares	3	5-7	

2.1.5.4 Data Quality Notifications

Table 12 shows current criteria used to determine when Data Quality Notifications (DQNs) are produced. If the thresholds are met, the algorithm stores a DQN to DMS indicating the tests that failed and the values that caused the failure. The DQNs are used by DQM for quality monitoring. Table 12 also contains the criteria used to trigger a DQN as well as the text contained in the DQN. The DQN criteria is contained in data quality threshold tables (DQTTs) produced by DQM. If the CrIMSS algorithm cannot obtain a DQTT for an EDR, the algorithm still executes, but no DQN tests are run. DQNs can be issued for the AVTP, AVMP, and PP EDRs as well as the Ozone IP product.

Table 12. Data Quality Notification Criteria

Test Description	Threshold	Text	Action
Product Yield (Percent of retrievals within granule with high quality of retrieval)	configurable (0 – 100%)	CrIMSS percent of retrievals with high quality retrievals is less than threshold	Send DQN if less than threshold
CrIS Input Data Quality (Percent of retrieved pixels with high quality input values for CrIS SDR)	configurable (0 – 100%)	CrIMSS percent of retrievals with high quality CrIS SDR input is less than threshold	Send DQN if less than threshold
ATMS Input Data Quality (Percent of retrieved pixels with high quality input values for ATMS SDR)	configurable (0 – 100%)	CrIMSS percent of retrievals with high quality ATMS SDR input is less than threshold	Send DQN if less than threshold

2.1.6 Computational Precision Requirements

The code uses single precision (real and integer) variables in most of the subroutines and functions. However, double precision real variables are required in the matrix inversion for computational accuracy.

2.1.7 Algorithm Support Considerations

The CrIMSS EDR algorithm relies on a fast Radiative Transfer Model (RTM) to compute MW and IR spectral radiances and the associated Jacobians (the change in spectral radiance with respect to geophysical parameters) for a given set of atmospheric profiles (temperature, water vapor, ozone, etc.), surface conditions (reflectivity and emissivity), viewing geometry, etc. The fast model (for both MW and IR) is built upon the OSS approach. All IR/MW forward model coefficient tables are generated offline.

There are three inputs for the OSS MW forward model. One is accessed from DMS using the CrimssIrOssCoeffsType structure which contains the OSS coefficients and channel information. Another input consists of the absorption coefficients tabulated at pressure layers, temperature and water vapor values and is accessed from DMS using the CrimssIrAbsorpCoeffsType structure. A third input consists of channel information, including frequency and polarization, and is accessed from DMS using the CrimssMwFrqPolType structure.

The OSS IR files are essentially the same formats as the MW files but there are only two inputs. The first one contains OSS coefficients and is accessed using the CrimssMwOssCoeffsType structure. The second one contains tabulated absorption coefficients and is accessed with the CrimssMwAbsorpCoeffsType structure. For water vapor, the tables are stratified by temperature and two water vapor amounts. For gases other than water vapor, stratification is only by temperature. The tables have both "*fixed*" and "*variable*" gases.

Lapack libraries are used in the retrieval code. The lapack routines also require that BLAS libraries are available.

2.1.7.1 Runtime Configurable Parameters

Table 13 lists CrIMSS EDR algorithm adjustable parameters and their values.

Table 13. List of Algorithm Parameters

Type	Algorithm Parameter	Description	Assigned Values
Int32	LocalAngleAdj	Flag to perform local angle adjustments	1 = perform LAA
Int32	Itrop	Flag to determine whether to find the trop	1 = find tropopause level
Int32	MwCloud	Flag for Cloud retrieval	1 = perform retrieval
Int32	covSelectMethod	Covariance selection method	3
Int32 [ ]	ChanSelFlag	Vector of channel selection flag for MW	Array of size 22 with either 0 or 1
Int32	LandTypes	LandTypes used in the algorithm	1 – 8
Int32	FovFac	Additional flag for MW Channels 1 and 2	0.0
Int32	apodFlag	Apodization option flag	2
Int32	maxMwIter	Maximum number of iterations for MW retrieval	7
Int32	maxIrIter	Maximum number of iterations for IR+MW retrieval	4
Int32	sceneClassMode	Scene classification mode	3
Float32	freqIrSfcHp	Surface hinge points for IR emissivity	680.0, 780.0, 815.0, 850.0, 900.0, 925.0, 950.0, 1214.0, 1245.0, 1300.0, 2200.0, 2550.0
Float32	bkgCld	Cloud background	0.1, 640.0
Float32	cldRetrCov	Cloud retrieval covariance	25.0, 0.0, 0.0, 0.5E-03
Float32	chanFlagLowerMin	Lower bound of lower minimum	660.0
Float32	chanFlagLowerMax	Upper bound of lower minimum	950.0
Float32	chanFlagUpperMin	Lower bound of upper minimum	1210.0
Float32	chanFlagUpperMax	Upper bound of upper minimum	1580.0
Float32	maxTemp	Maximum temperature	400.0
Float32	minTemp	Minimum temperature	50.0
Float32	alpha1	Constant used to calculate error covariance matrix	2.0
Float32	chiSqMwIterThresh	MW convergence flag to finish iteration	0.9
Float32	chiSqMwThresh	Threshold used to determine when to reset background and covariance	0.9
Float32	chiSqCldThresh	Cloudy radiance convergence criterion	0.8
Float32	chiSqIrThresh	Convergence threshold to finish IR iterations	0.7
Float32	htol	Constant used for checking missing ration for super-saturation	1.6
Int32	debug	Debug flag	1 = debug print on
Float32	landThresh	Land threshold (percentage of land)	0.6
Float32	oceanThresh	Ocean threshold (percentage of ocean)	0.3
Float32	tSkinMwThreshold1	Threshold used to determine covariance matrices in setCovBack routine	240.0
Float32	tSkinMwThreshold2	Threshold used to determine covariance matrices in setCovBack routine	260.0
Float32	tSkinMwThreshold3	Threshold used to determine covariance matrices in setCovBack routine	280.0
Float32	tSkinMwThreshold4	Threshold used to determine covariance matrices in setCovBack routine	290.0

Type	Algorithm Parameter	Description	Assigned Values
Float32	firstCldTunApod0	First cloud-clearing tuning parameter apodization = 0	0.7
Float32	firstCldTunApod1	First cloud-clearing tuning parameter apodization = 1	1.2
Float32	firstCldTunApod2	First cloud-clearing tuning parameter apodization = 2	4.5
Float32	secondCldTunApod0	Second cloud-clearing tuning parameter apodization = 0	0.7
Float32	secondCldTunApod1	Second cloud-clearing tuning parameter apodization = 1	1.4
Float32	secondCldTunApod2	Second cloud-clearing tuning parameter apodization = 2	6.0
Float32	cldClearRngBnd1	Cloud-clearing spectral range for band 1	709.5, 746.0
Float32	cldClearRngBnd3	Cloud-clearing spectral range for band 3	2190.0, 2250.0
Int32	atmNoise	Atmospheric noise flag used in FOV selection routine	0
Float32	irChanRangeNotUsed	Range of IR channels not used in the retrieval	1580.0, 2155.0
Float32	cloudIEmissAndRefl	Emissivity and reflectivity of cloud I for all channels	0.0
Float32	irECMSpectRangeLow	IR lower spectral range to calculate error covariance matrix	650.0, 680.0
Float32	irECMSpectRangeHigh	IR higher spectral range to calculate error covariance matrix	2320.0, 2370.0
Float32	chSqAirsMax	Threshold for chi-square value calculated using AIRS method	0.5
Float32	chiSqMax	Second stage chi-square threshold	1.0
Float32	chiSqMwMax	First stage (MW only) chi-square threshold	2.0
Float32	chiSqMw2Max	Second stage MW chi-square threshold	2.0
Float32	profDiffMax	First vs second stage retrieval profile difference threshold	3.0
Float32	ccThreshIrMw	Cloud/Clear threshold for the second stage chisquare value	1.0
Float32	ccThreshMw	Cloud/Clear threshold for the first stage chisquare value	1.0
Float32	ccThreshIrna	Cloud/Clear threshold for the IR Noise Amplification Factor value	2.0
Float32	sunGlintThresh	Sun glint threshold (degrees)	36.0
Int32[]	detectorQF	Detector failure flags (0=failure,1=ok)	Array of size 27 (3 bands x 9 detectors) with either 0 or 1

2.1.8 Assumptions and Limitations

Several assumptions and limitations associated with this algorithm are discussed in Sections 2.1.8.1 and 2.1.8.2.

2.1.8.1 Assumptions

Listed below are assumptions applicable for the implemented algorithm.

AVTP, AVMP, and PP EDRs receive calibrated and geolocated TOA IR/MW sensors spectral radiances in the bands used by the CrIMSS.

Sensor-specific noise and auxiliary files are necessary.

Global background and covariance files are necessary.

NWP databases for pre-processing are needed if the MW instrument is inactive.

2.1.8.2 Limitations

The IR spectral radiances are contaminated by clouds. The scene classification is to identify the cloud conditions within an FOR. It is essential for optimizing the retrieval quality and interpolation. The PCA and CC approaches are used to estimate the number of cloud formations in FOR and clear spectral radiances for each FOV cluster, and perform the retrieval on these clear spectral radiances. However, non-cloud inhomogeneities within the scene could cause misclassification and induce large error into the cloud-clear retrieval, thus, it degrades the retrieval performance.

Sub-FOV cloud variability has the potential of seriously degrading retrieval performance. This degradation is largest in situations when none of the FOVs is cloud-free, the cloud fractions are large, and, for the particular cloud scene considered, it is caused primarily by the variability in cloud-top distribution. It is difficult to assess how representative this particular scene is of global cloud condition.

The impact of special and temporal variability of trace gas (O_3, N_2O, CO, and CH_4) needs to be properly accounted for in the OSS model. In the current algorithm, this has been ameliorated by introducing empirical error terms involving the derivatives of spectral radiance with respect to column amounts of O_3 and N_2O under a variety of cloud conditions.

3.0 GLOSSARY/ACRONYM LIST

3.1 Glossary

The current glossary for the NPOESS program, D35836_E_NPOESS_Glossary, can be found on eRooms. Table 14 contains those terms most applicable for this OAD.

Table 14. Glossary

Term	Description
Algorithm	A formula or set of steps for solving a particular problem. Algorithms can be expressed in any language, from natural languages like English to mathematical expressions to programming languages like FORTRAN. On NPOESS, an algorithm consists of: 1. A theoretical description (i.e., science/mathematical basis) 2. A computer implementation description (i.e., method of solution) 3. A computer implementation (i.e., code)
Algorithm Configuration Control Board (ACCB)	Interdisciplinary team of scientific and engineering personnel responsible for the approval and disposition of algorithm acceptance, verification, development and testing transitions. Chaired by the Algorithm Implementation Process Lead, members include representatives from IWPTB, Systems Engineering & Integration IPT, System Test IPT, and IDPS IPT.
Algorithm Verification	Science-grade software delivered by an algorithm provider is verified for compliance with data quality and timeliness requirements by Algorithm Team science personnel. This activity is nominally performed at the IWPTB facility. Delivered code is executed on compatible IWPTB computing platforms. Minor hosting modifications may be made to allow code execution. Optionally, verification may be performed at the Algorithm Provider's facility if warranted due to technical, schedule or cost considerations.
EDR Algorithm	Scientific description and corresponding software and test data necessary to produce one or more environmental data records. The scientific computational basis for the production of each data record is described in an ATBD. At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.
Environmental Data Record (EDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to geophysical parameters (including ancillary parameters, e.g., cloud clear radiation, etc.). *[Supplementary Definition]* An Environmental Data Record (EDR) represents the state of the environment, and the related information needed to access and understand the record. Specifically, it is a set of related data items that describe one or more related estimated environmental parameters over a limited time-space range. The parameters are located by time and Earth coordinates. EDRs may have been resampled if they are created from multiple data sources with different sampling patterns. An EDR is created from one or more NPOESS SDRs or EDRs, plus ancillary environmental data provided by others. EDR metadata contains references to its processing history, spatial and temporal coverage, and quality.
Operational Code	Verified science-grade software, delivered by an algorithm provider and verified by IWPTB, is developed into operational-grade code by the IDPS IPT.
Operational-Grade Software	Code that produces data records compliant with the System Specification requirements for data quality and IDPS timeliness and operational infrastructure. The software is modular relative to the IDPS infrastructure and compliant with IDPS application programming interfaces (APIs) as specified for TDR/SDR or EDR code.

Term	Description
Raw Data Record (RDR)	*[IORD Definition]* Full resolution digital sensor data, time referenced and earth located, with absolute radiometric and geometric calibration coefficients appended, but not applied, to the data. Aggregates (sums or weighted averages) of detector samples are considered to be full resolution data if the aggregation is normally performed to meet resolution and other requirements. Sensor data shall be unprocessed with the following exceptions: time delay and integration (TDI), detector array non-uniformity correction (i.e., offset and responsivity equalization), and data compression are allowed. Lossy data compression is allowed only if the total measurement error is dominated by error sources other than the data compression algorithm. All calibration data is retained and communicated to the ground without lossy compression. *[Supplementary Definition]* A Raw Data Record (RDR) is a logical grouping of raw data output by a sensor, and related information needed to process the record into an SDR or TDR. Specifically, it is a set of unmodified raw data (mission and housekeeping) produced by a sensor suite, one sensor, or a reasonable subset of a sensor (e.g., channel or channel group), over a specified, limited time range. Along with the sensor data, the RDR includes auxiliary data from other portions of NPOESS (space or ground) needed to recreate the sensor measurement, to correct the measurement for known distortions, and to locate the measurement in time and space, through subsequent processing. Metadata is associated with the sensor and auxiliary data to permit its effective use.
Retrieval Algorithm	A science-based algorithm used to ‘retrieve’ a set of environmental/geophysical parameters (EDR) from calibrated and geolocated sensor data (SDR). Synonym for EDR processing.
Science Algorithm	The theoretical description and a corresponding software implementation needed to produce an NPP/NPOESS data product (SDR or EDR). The former is described in an ATBD. The latter is typically developed for a research setting and characterized as “science-grade”.
Science Algorithm Provider	Organization responsible for development and/or delivery of SDR or EDR algorithms associated with a given sensor.
Science-Grade Software	Code that produces data records in accordance with the science algorithm data quality requirements. This code, typically, has no software requirements for implementation language, targeted operating system, modularity, input and output data format or any other design discipline or assumed infrastructure.
SDR Algorithm	Scientific description and corresponding software and test data necessary to produce a Sensor Data Record given a sensor’s Raw Data Record. The scientific computational basis for the production of each data record is described in an Algorithm Theoretical Basis Document (ATBD). At a minimum, implemented software is science-grade and includes test data demonstrating data quality compliance.

Term	Description
Sensor Data Record (SDR)	*[IORD Definition]* Data record produced when an algorithm is used to convert Raw Data Records (RDRs) to calibrated brightness temperatures with associated ephemeris data. The existence of the SDRs provides reversible data tracking back from the EDRs to the Raw data. *[Supplementary Definition]* A Sensor Data Record (SDR) is the recreated input to a sensor, and the related information needed to access and understand the record. Specifically, it is a set of incident flux estimates made by a sensor, over a limited time interval, with annotations that permit its effective use. The environmental flux estimates at the sensor aperture are corrected for sensor effects. The estimates are reported in physically meaningful units, usually in terms of an angular or spatial and temporal distribution at the sensor location, as a function of spectrum, polarization, or delay, and always at full resolution. When meaningful, the flux is also associated with the point on the Earth geoid from which it apparently originated. Also, when meaningful, the sensor flux is converted to an equivalent top-of-atmosphere (TOA) brightness. The associated metadata includes a record of the processing and sources from which the SDR was created, and other information needed to understand the data.

3.2 Acronyms

The current acronym list for the NPOESS program, D35838_E_NPOESS_Acronyms, can be found on eRooms. Table 15 contains those terms most applicable for this OAD.

Table 15. Acronyms

Acronym	Description
AER	Atmospheric and Environment Research, Inc.
AIRS	Advanced Infrared Sounder
AMSU	Advanced Microwave Sounding Unit
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
ATBD	Algorithm Theoretical Basis Document
AVMP	Atmospheric Vertical Moisture Profile
PP	Atmospheric Vertical Pressure Profile
AVTP	Atmospheric Vertical Temperature Profile
CC	Cloud-clearing
CMIS	Conical Scanning Microwave Imager Sounder
CrIMSS	Cross-track Infrared and Microwave Sounder Suite
CrIS	Cross Track Infrared Sounder
DEM	Digital Elevation Map
DMS	Data Management Subsystem
DQN	Data Quality Notification
DQTT	Data Quality Threshold Table
EDR	Environmental Data Record
EOF	Empirical Orthogonal Function
FOR	Field Of Regard
FOV	Field Of View
FTS	Field Terminal Segment
HIRS	High-Resolution Infrared Sounder
HIS	High-Resolution Interferometric Spectrometer

Acronym	Description
HSB	Humidity Sounder Brazil
IDPS	Integrated Data Processing Segment
IPO	Integrated Program Office
IR	Infrared
LA	Low Atmosphere
LAA	Local Angle Adjustment
LUT	Look-Up Table
LWIR	Climate Data Records
MHS	Microwave Humidity Sounder
MSU	Microwave Sounder Unit
MW	Microwave
MWIR	Midwave IR band
NASA	National Aeronautics and Space Administration
NAST	NPOESS Atmospheric Sounder Testbed
NCEP	National Center for Environmental Prediction
NEDN	Noise Equivalent Difference
NESDIS	National Environmental Satellite, Data, and Information Service
NOAA	National Oceanic and Atmospheric Administration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NRF	Noise Reduction Factor
NWP	Numerical Weather Prediction
OAD	Operational Algorithm Description Document
OSS	Optimal Spectral Sampling
PCA	Principal Component Analysis
PDR	Preliminary Design Review
PP	Pressure Profile
QC	Quality Control
RDR	Row Data Record
RMS	Root Mean Square
RT	Radiative Transfer
RTE	Radiative Transfer Equation
RTM	Radiative Transfer Model
SDR	Sensor Data Record
SGI	Silicon Graphics, Inc.
SRF	Sensor Response Function
SSM/I	Special Sensor Microwave/Imager
SWIR	Shortwave IR band
TIGR	TOVS Initial Guess Retrieval
TOA	Top Of Atmosphere
TOVS	TIROS-N Operational Vertical Sounder
UA	Upper Atmosphere
VCM	VIIRS Cloud Map
VIIRS	Visible/Infrared Imager/Radiometer Suite
WPTB	Weather Products Test Bed

4.0 OPEN ISSUES

Table 16. TBXs

No.	DESCRIPTION	RESOLUTION DATE
TBS01	Need Susskind and Joiner reference	Unknown